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Mitsui et al.

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(54) **METHOD OF MANUFACTURING LAMINATED CORE**

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(73) Assignee: **Mitsui High-Tec, Inc.** (JP)

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(21) Appl. No.: **12/706,017**

(22) Filed: **Feb. 16, 2010**

(65) **Prior Publication Data**

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Related U.S. Application Data

(62) Division of application No. 10/573,867, filed on Mar. 29, 2006, now Pat. No. 7,698,803.

(30) **Foreign Application Priority Data**

Sep. 9, 2004	(JP)	2004-262541
Oct. 26, 2004	(JP)	2004-311198
Nov. 9, 2004	(JP)	2004-325201
Nov. 25, 2004	(JP)	2004-340510
Nov. 25, 2004	(JP)	2004-340511
Dec. 2, 2004	(JP)	2004-349848

(51) **Int. Cl.**
H02K 15/02 (2006.01)

(52) **U.S. Cl.** **29/598**; 29/596; 29/605; 29/609; 29/732; 310/254.1

(58) **Field of Classification Search** 29/596–598, 29/732–736; 310/254.1, 202, 216.001; 72/353.2, 72/363, 402

See application file for complete search history.

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Primary Examiner — Minh Trinh

(74) *Attorney, Agent, or Firm* — Wood, Phillips, Katz, Clark & Mortimer

(57) **ABSTRACT**

A method of manufacturing a laminated stator core includes: forming a band-shaped yoke core sub-piece having a shape that an outer half is developed in a straight line when a yoke portion of the laminated stator core is divided into two halves in the width direction by punching a metal plate; forming an outer laminated yoke body by winding and laminating the band-shaped yoke core sub-piece in a spiral shape and coupling it in a caulking manner; forming an inner yoke-attachment magnetic core sub-piece having an inner yoke sub-portion obtained by dividing the inner half in a unit of magnetic poles when the yoke portion of the laminated stator core is divided into two halves in the width direction, by punching a metal plate; forming an inner yoke-attachment laminated magnetic sub-body by laminating and coupling a predetermined number of the inner yoke-attachment magnetic core sub-pieces to each other in a caulking manner; forming an intermediate assembly in which the inner yoke sub-portions form a ring shape by winding a coil on the inner yoke-attachment laminated magnetic sub-body and connecting the ends of the inner yoke sub-portions in a predetermined number of the inner yoke-attachment laminated magnetic sub-bodies to each other; and coupling the inner yoke-attachment laminated magnetic sub-bodies to the outer laminated yoke body by shrink-fitting the outer laminated yoke body to the outer circumference of the intermediate assembly.

6 Claims, 67 Drawing Sheets

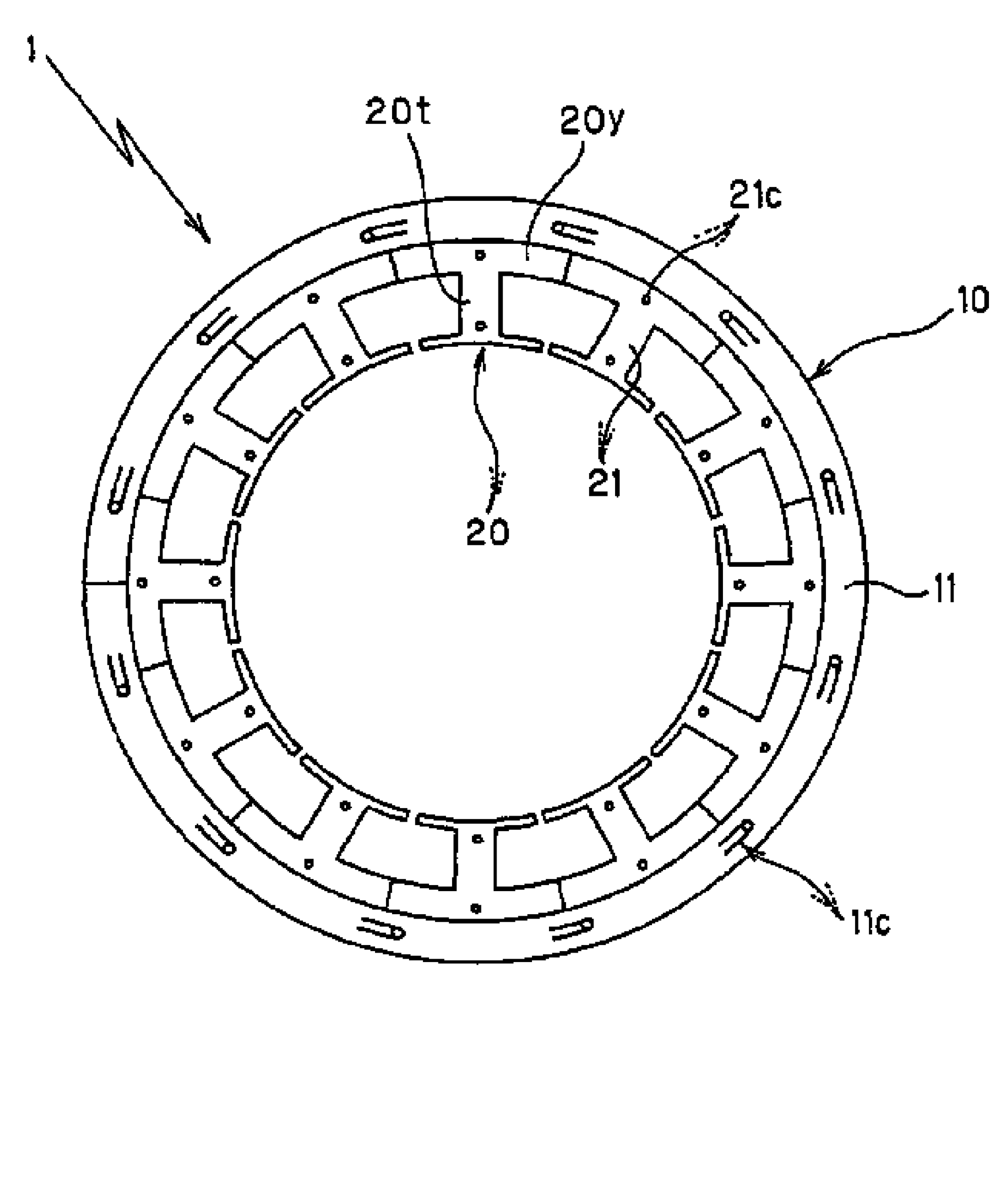

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Fig. 1A

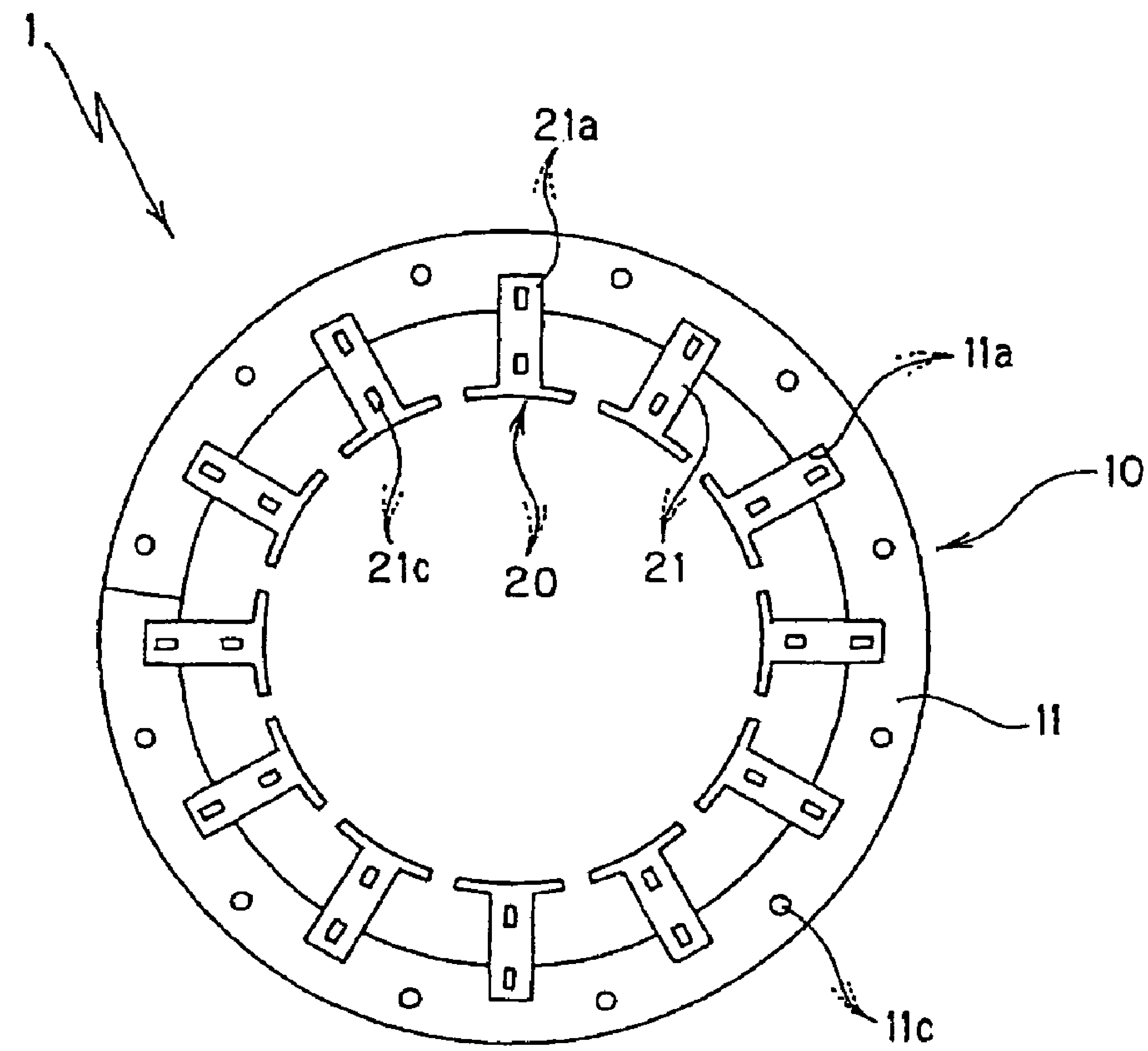
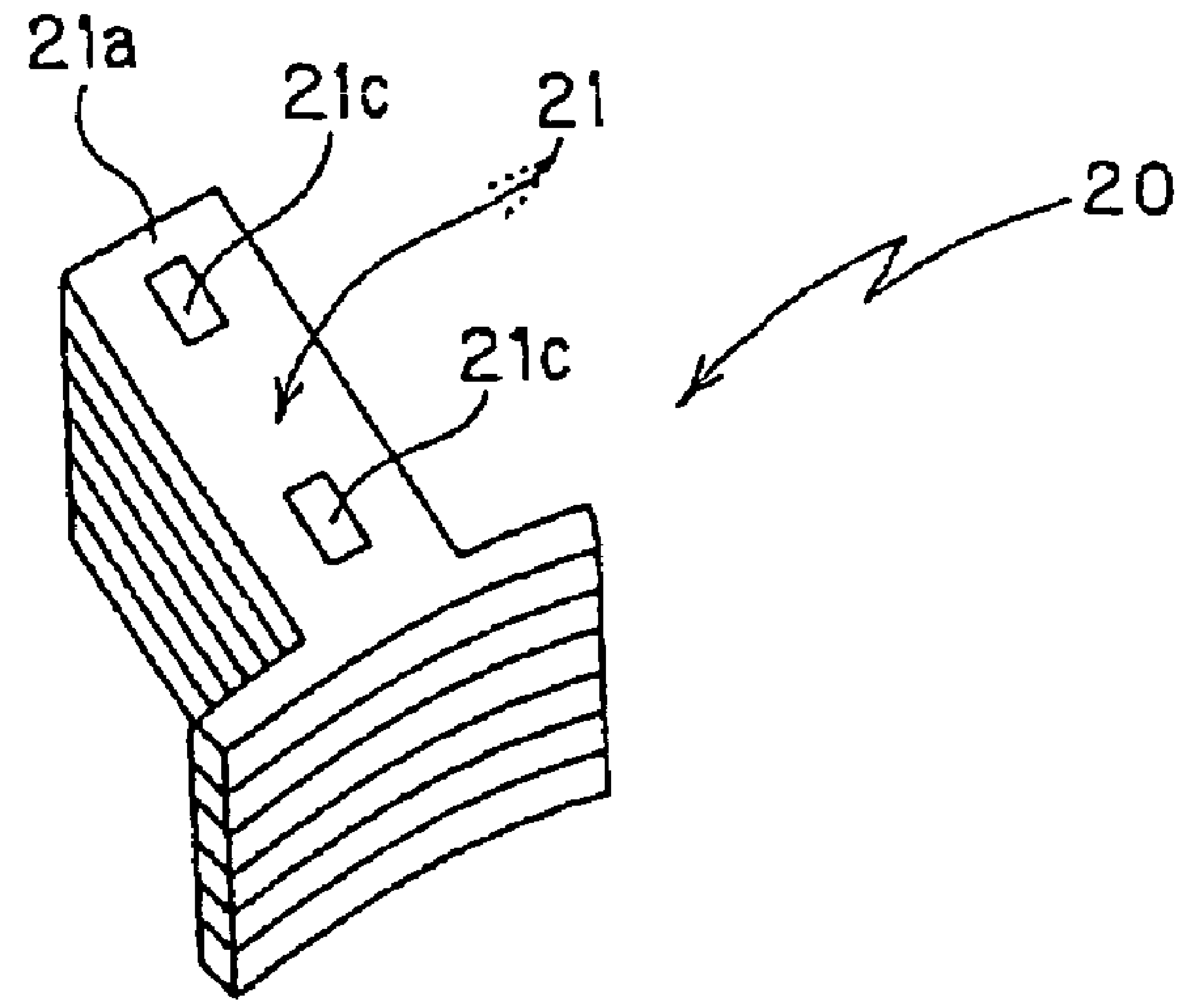


Fig. 1B

Fig. 2A



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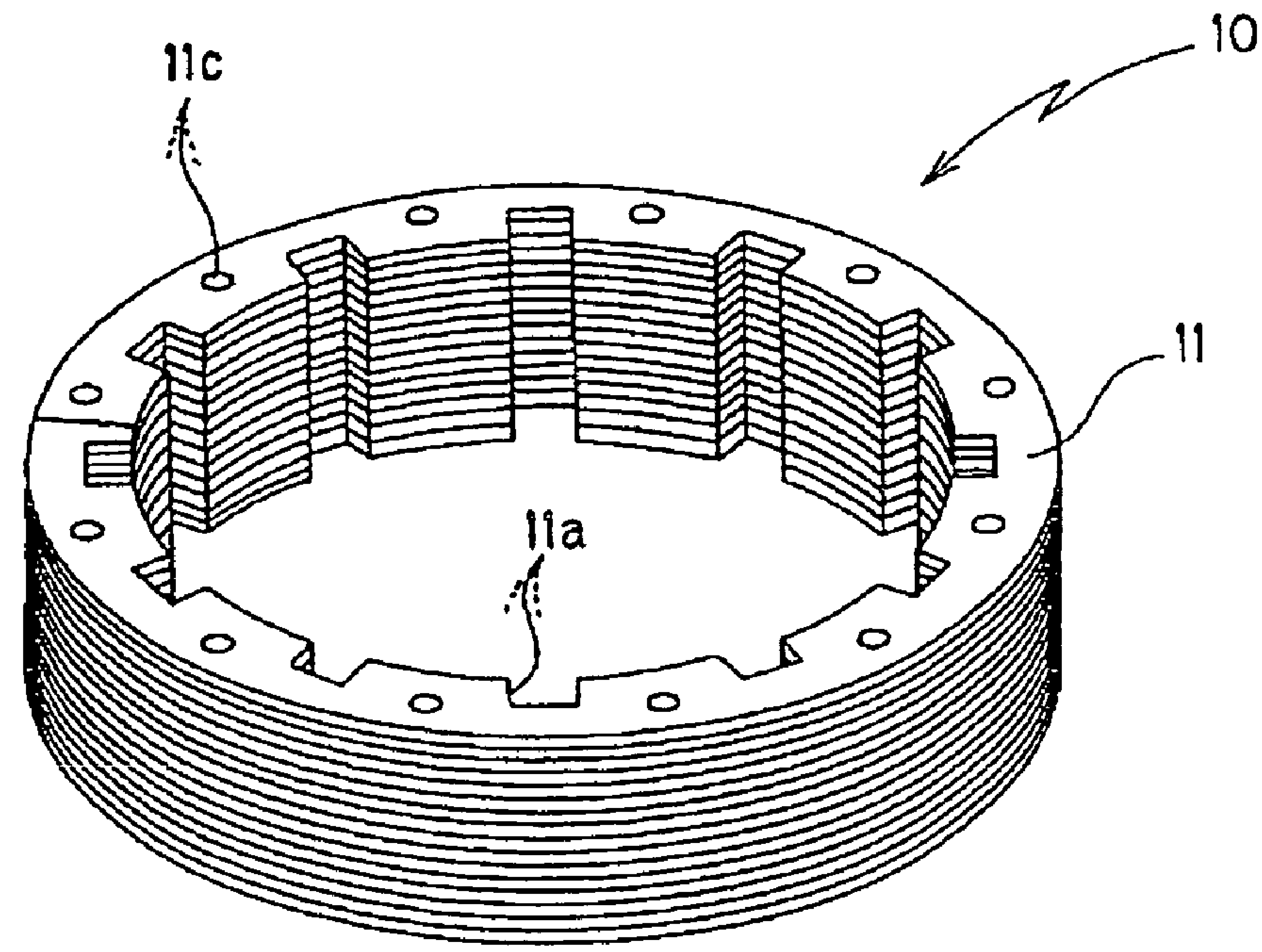

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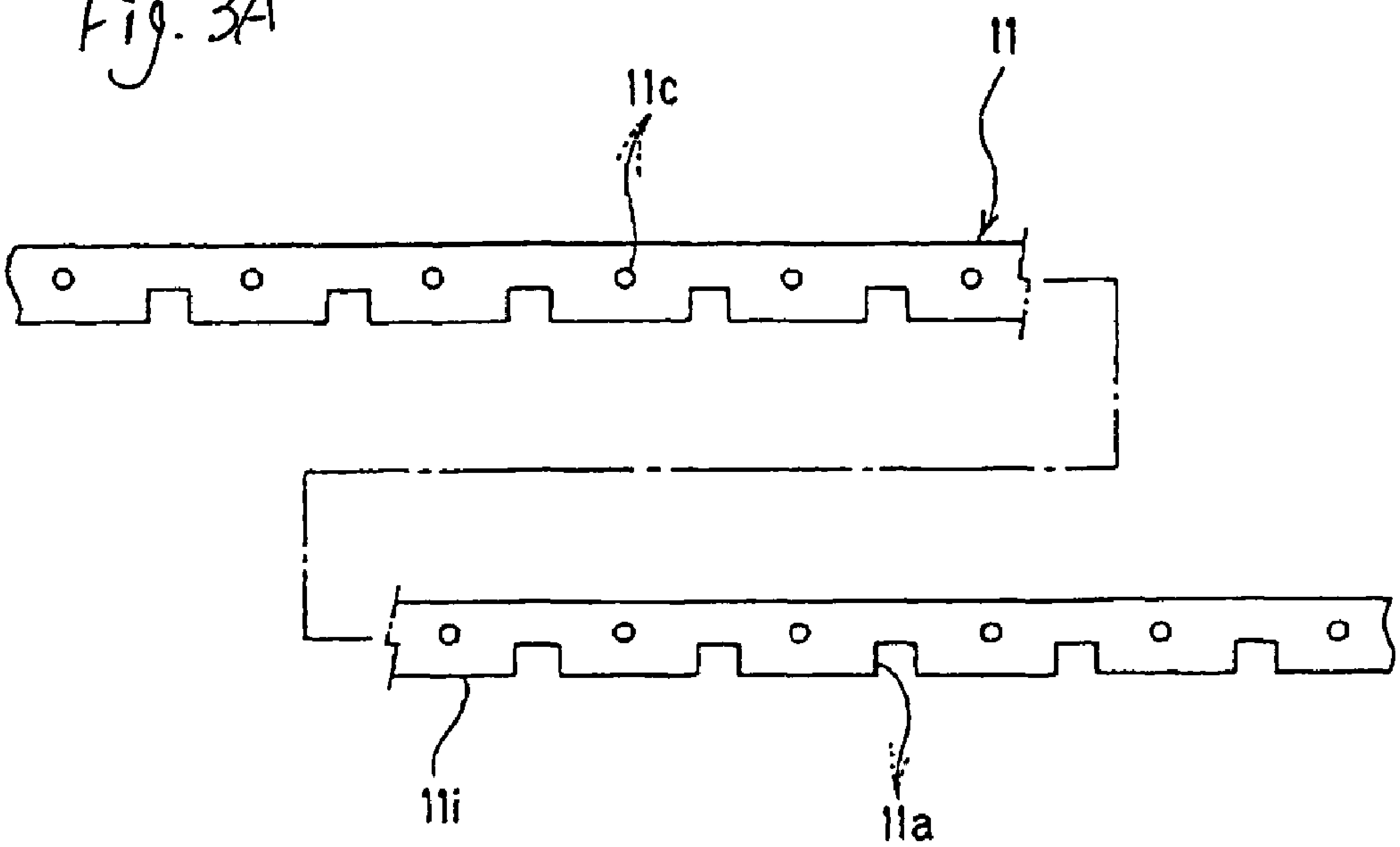

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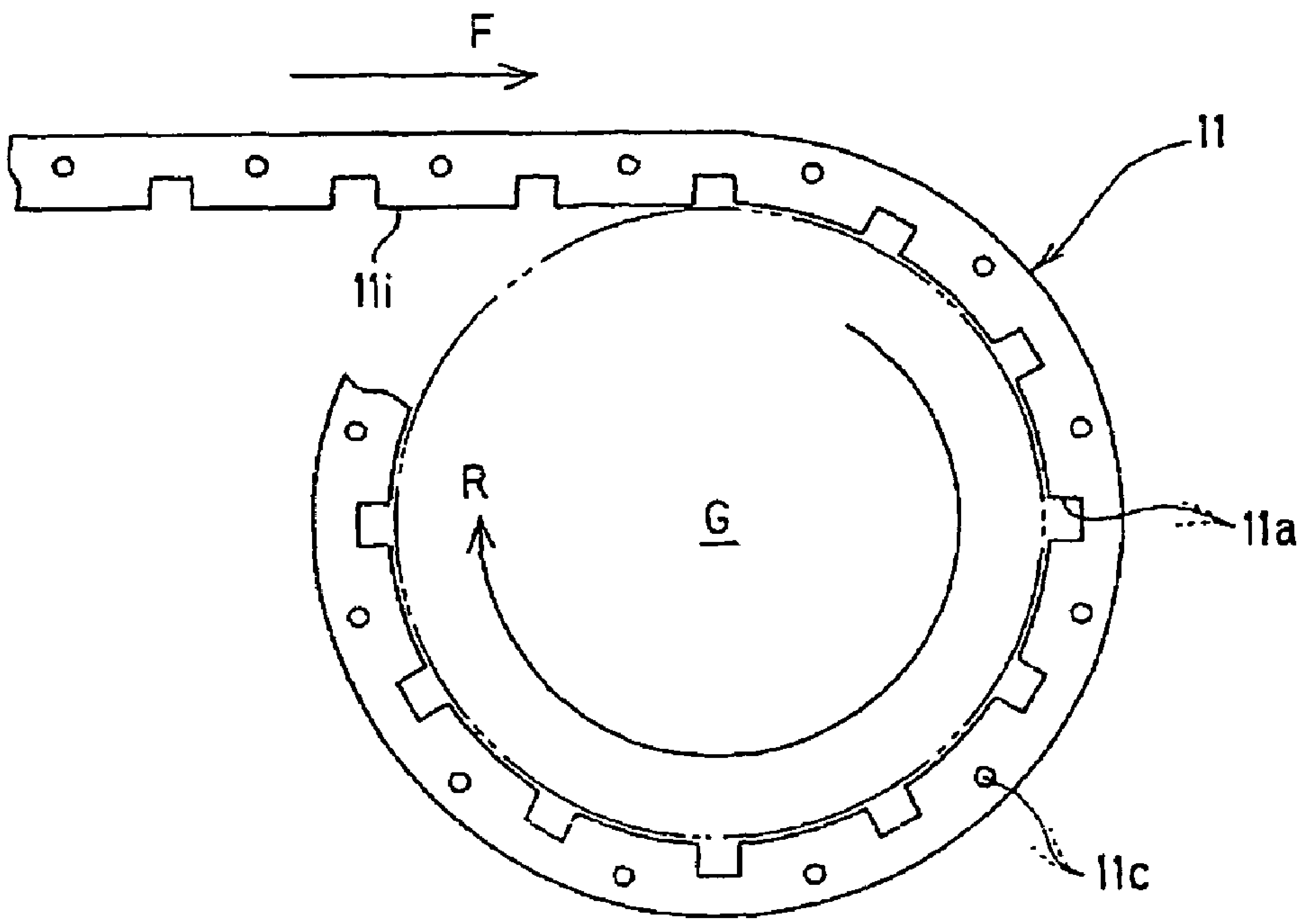

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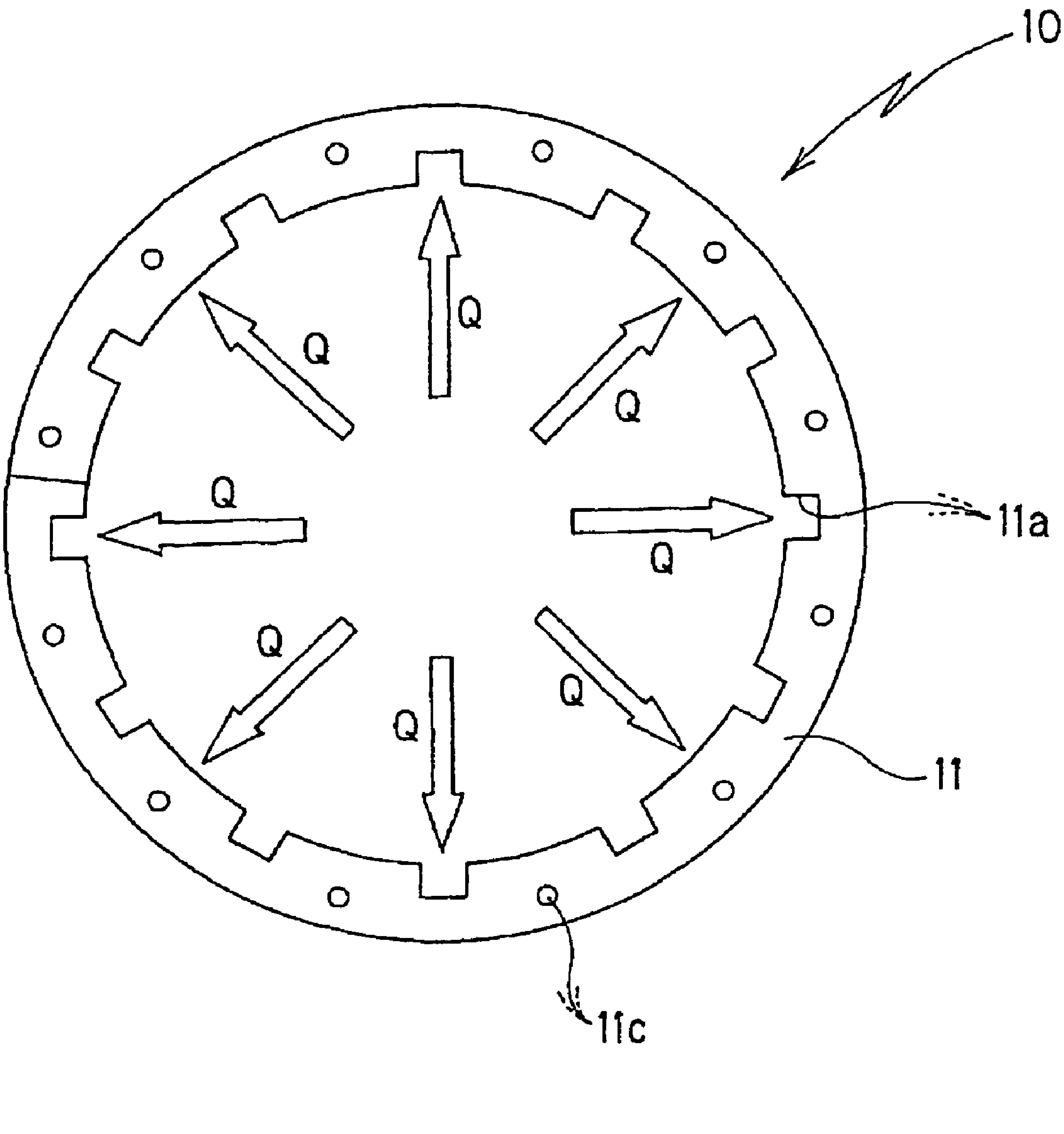

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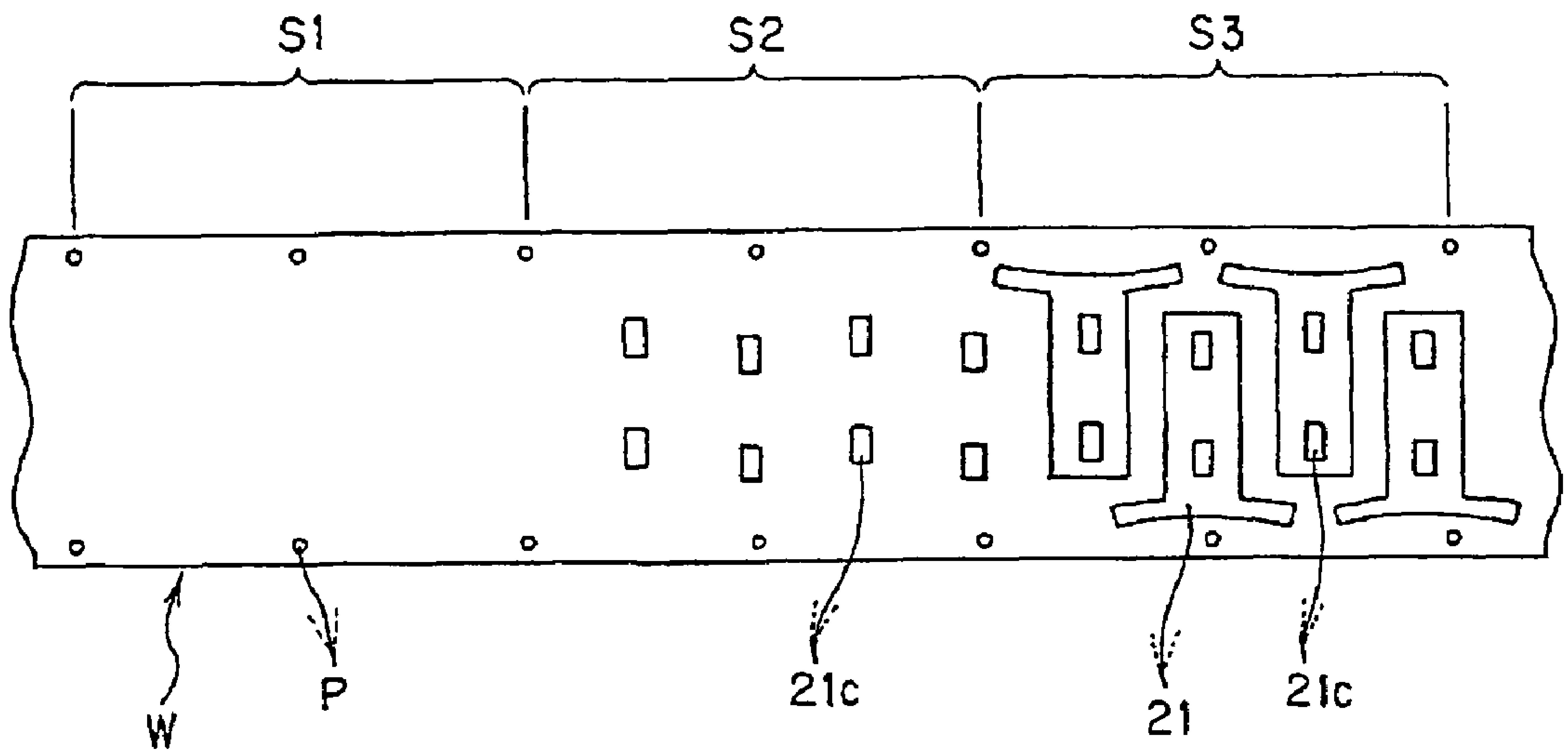

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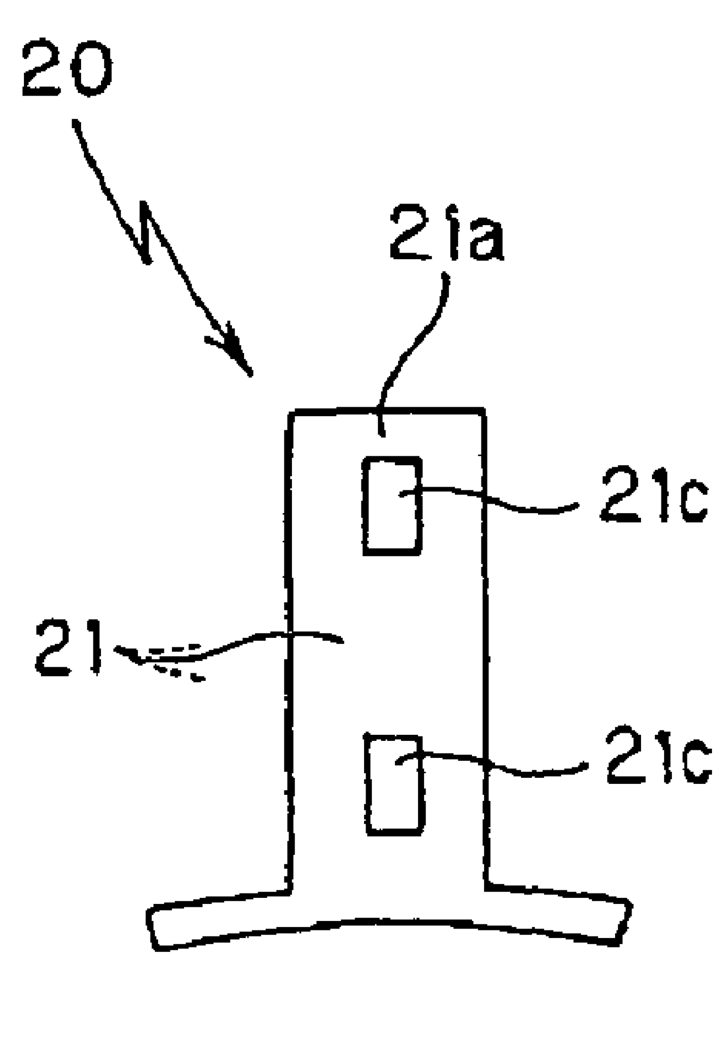
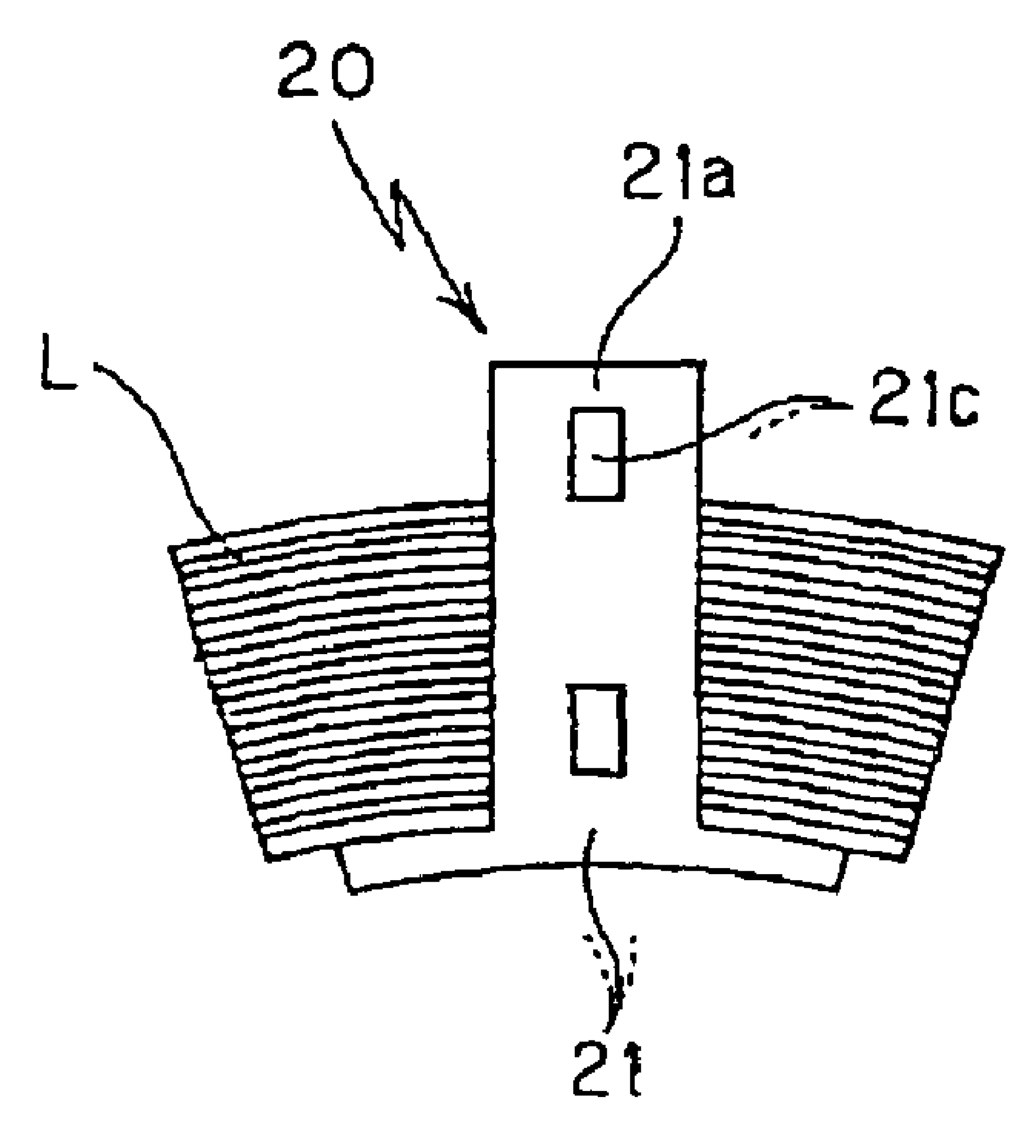


Fig. 5C



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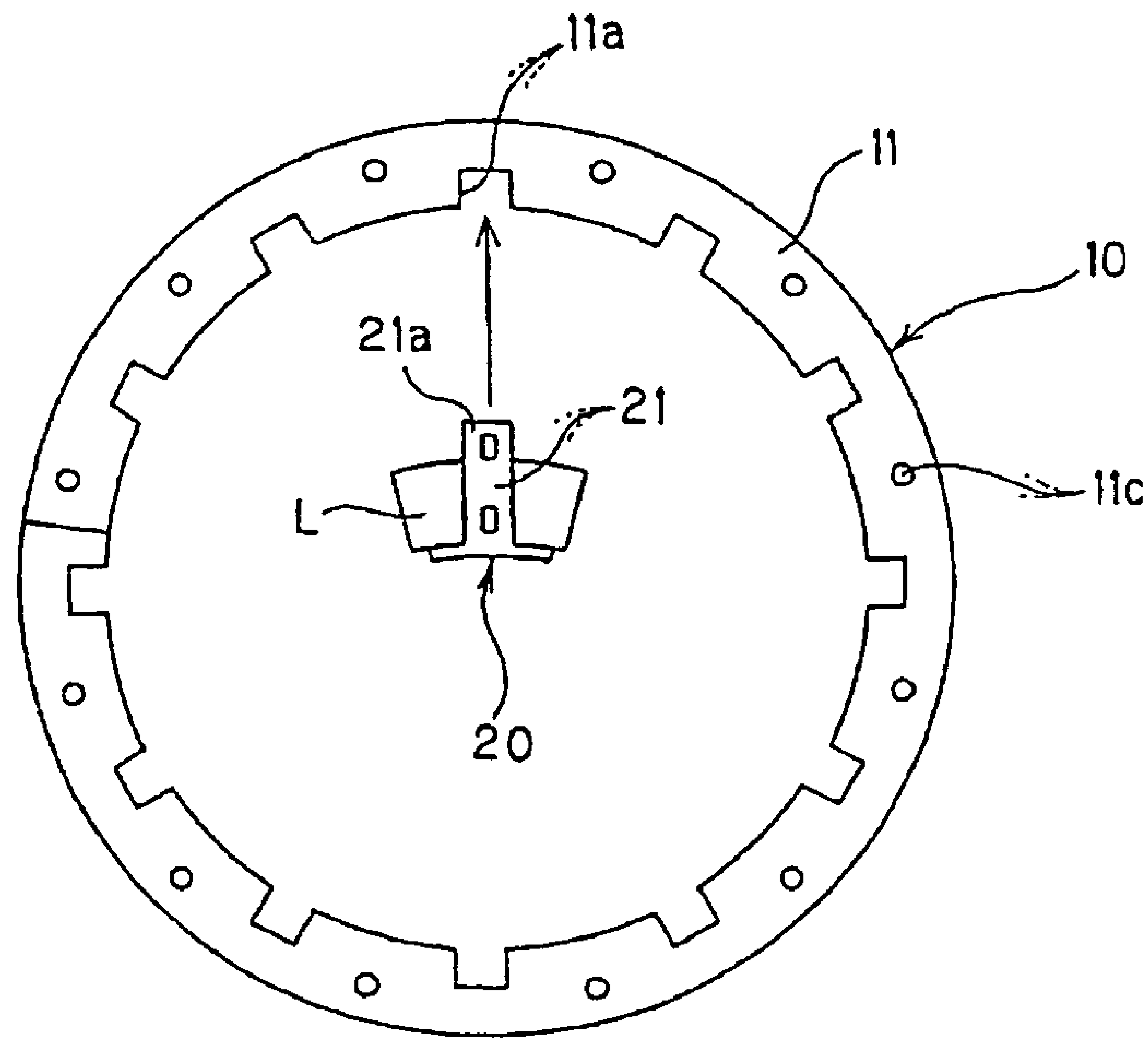

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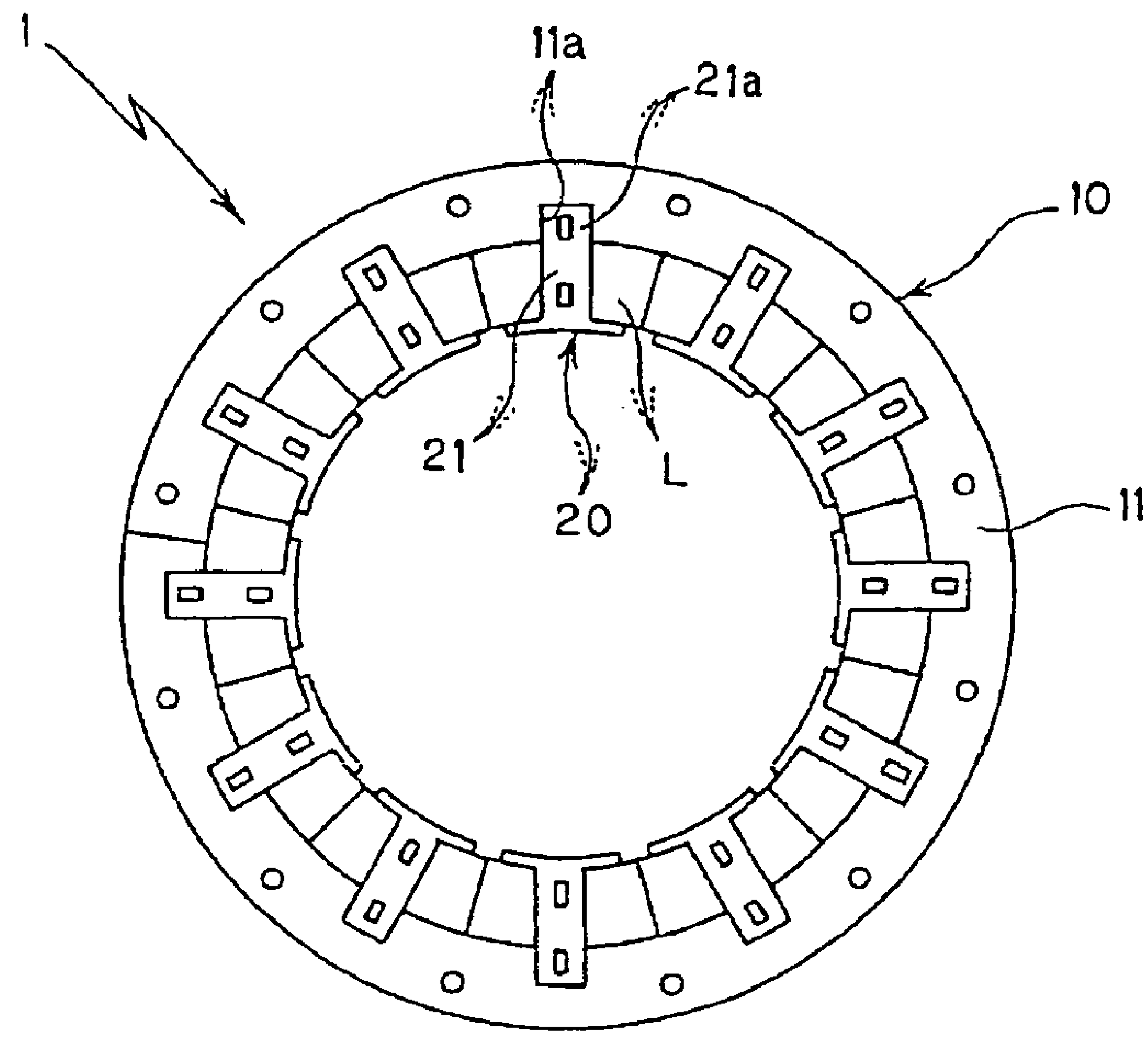

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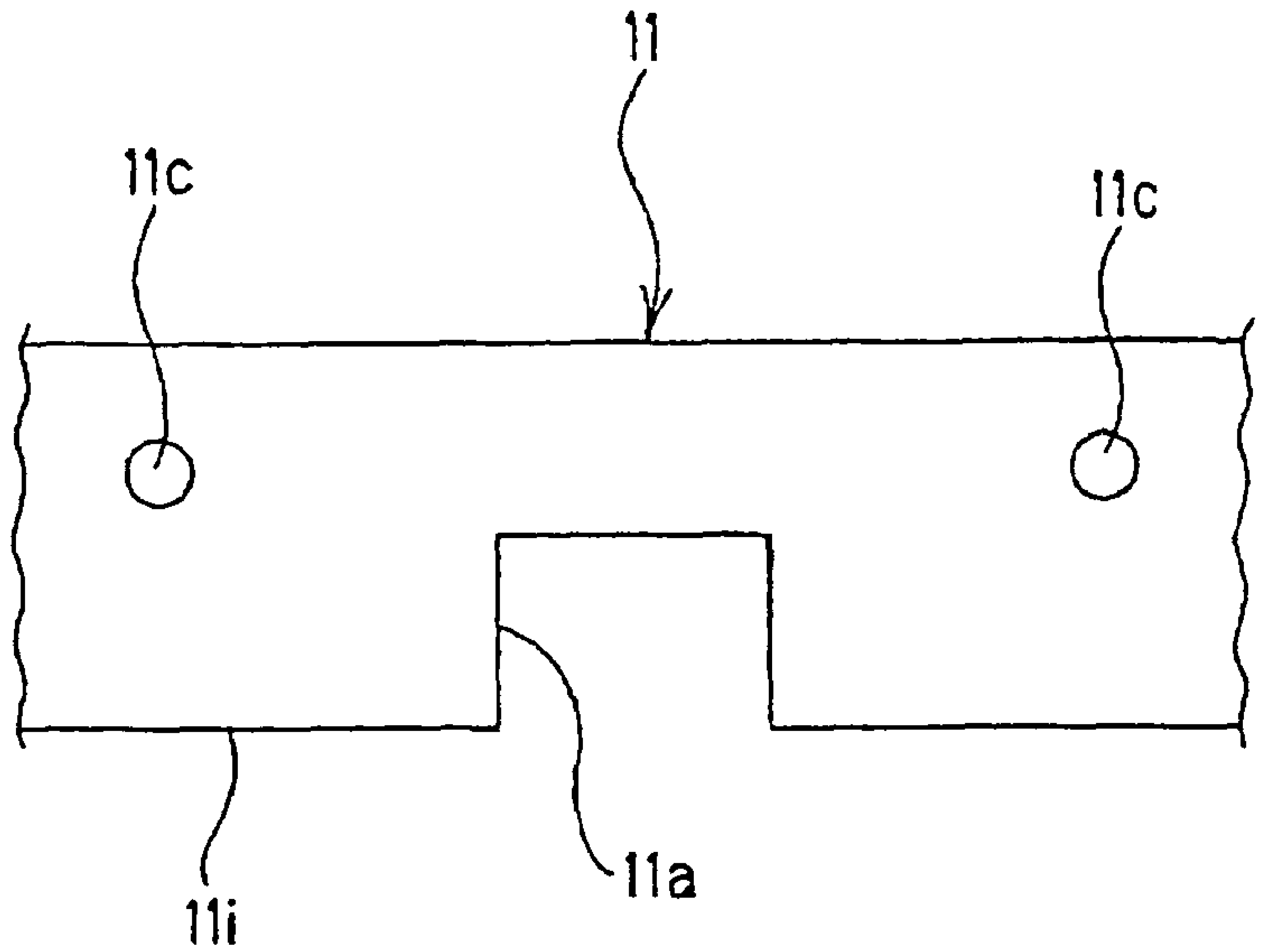

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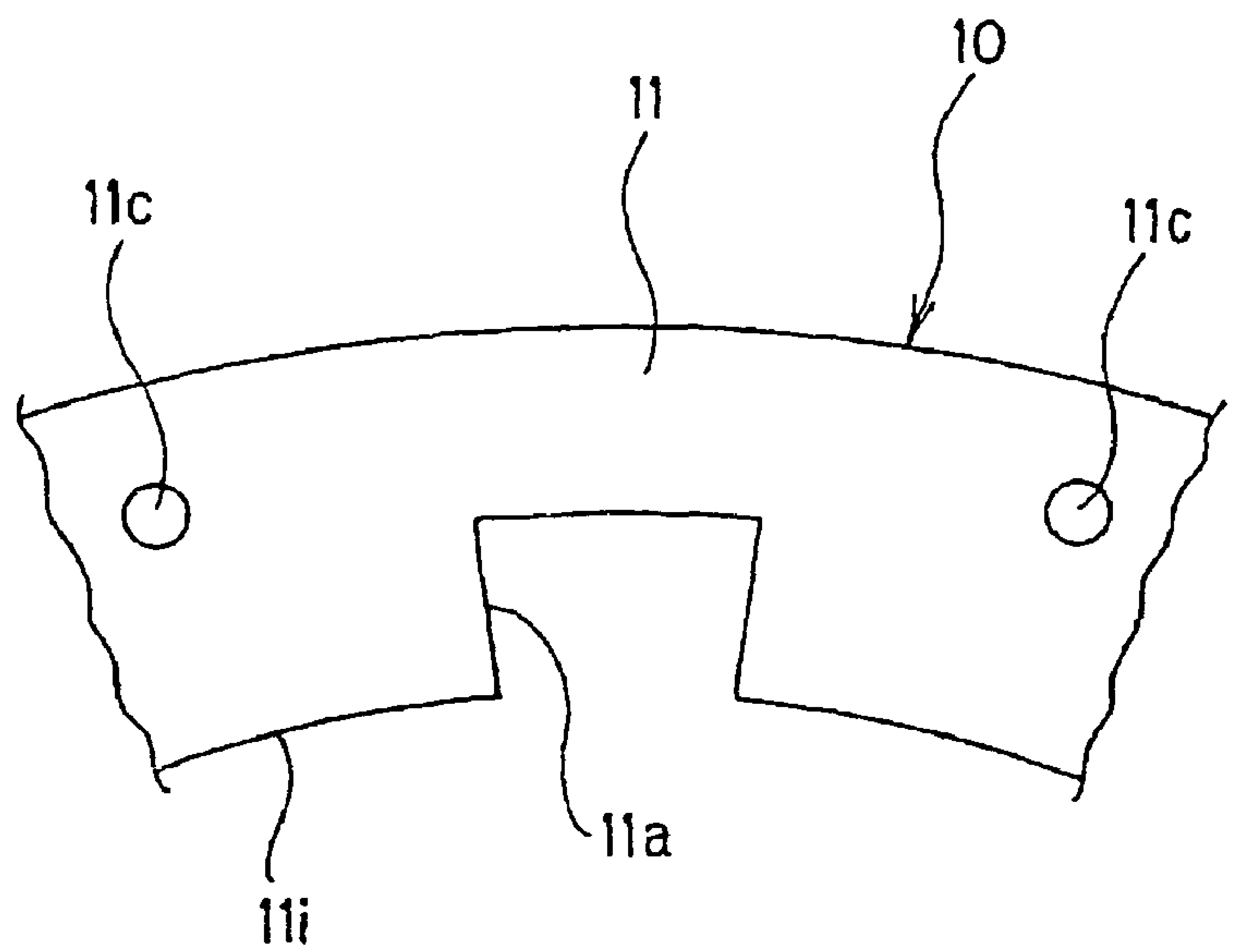

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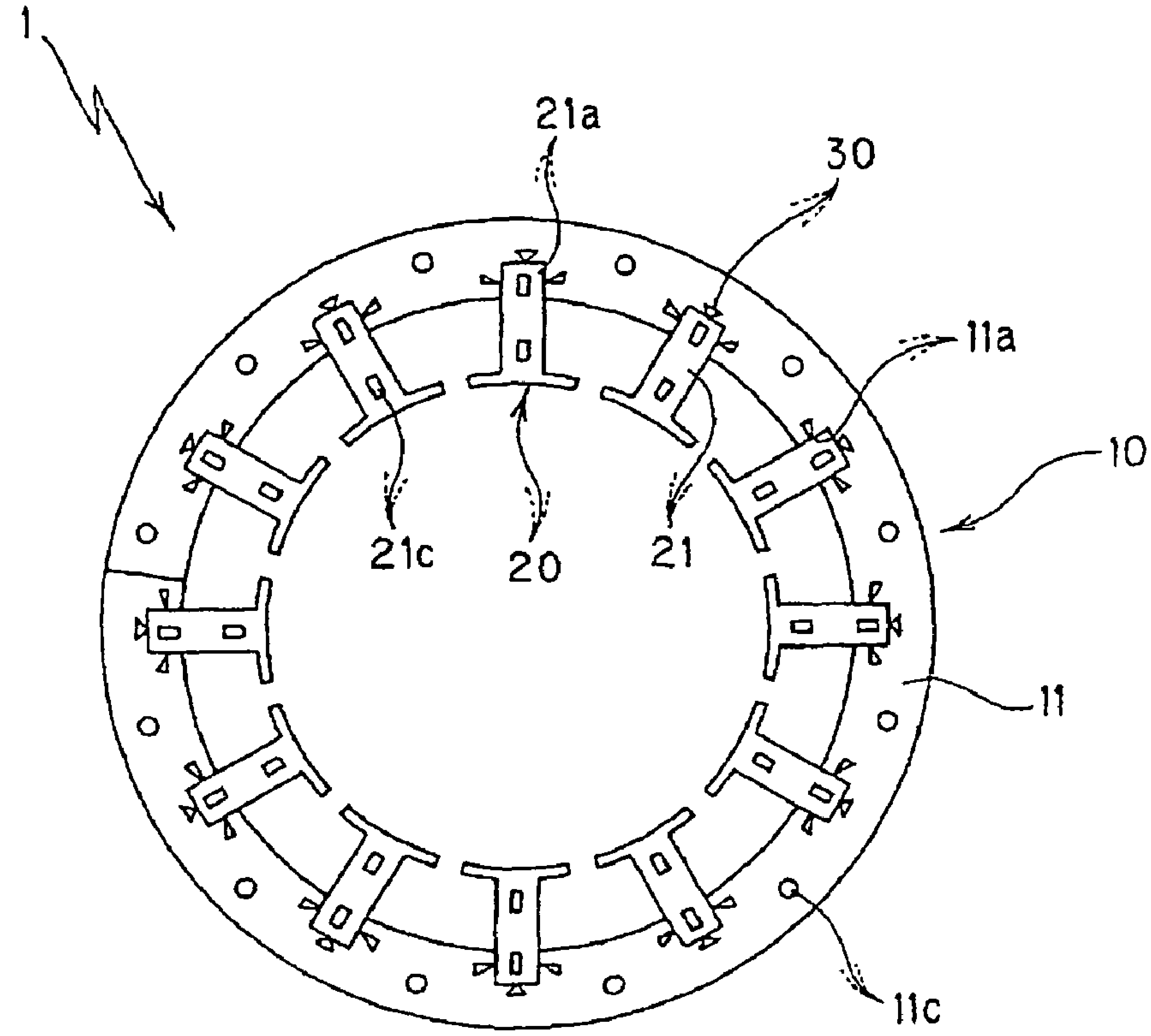

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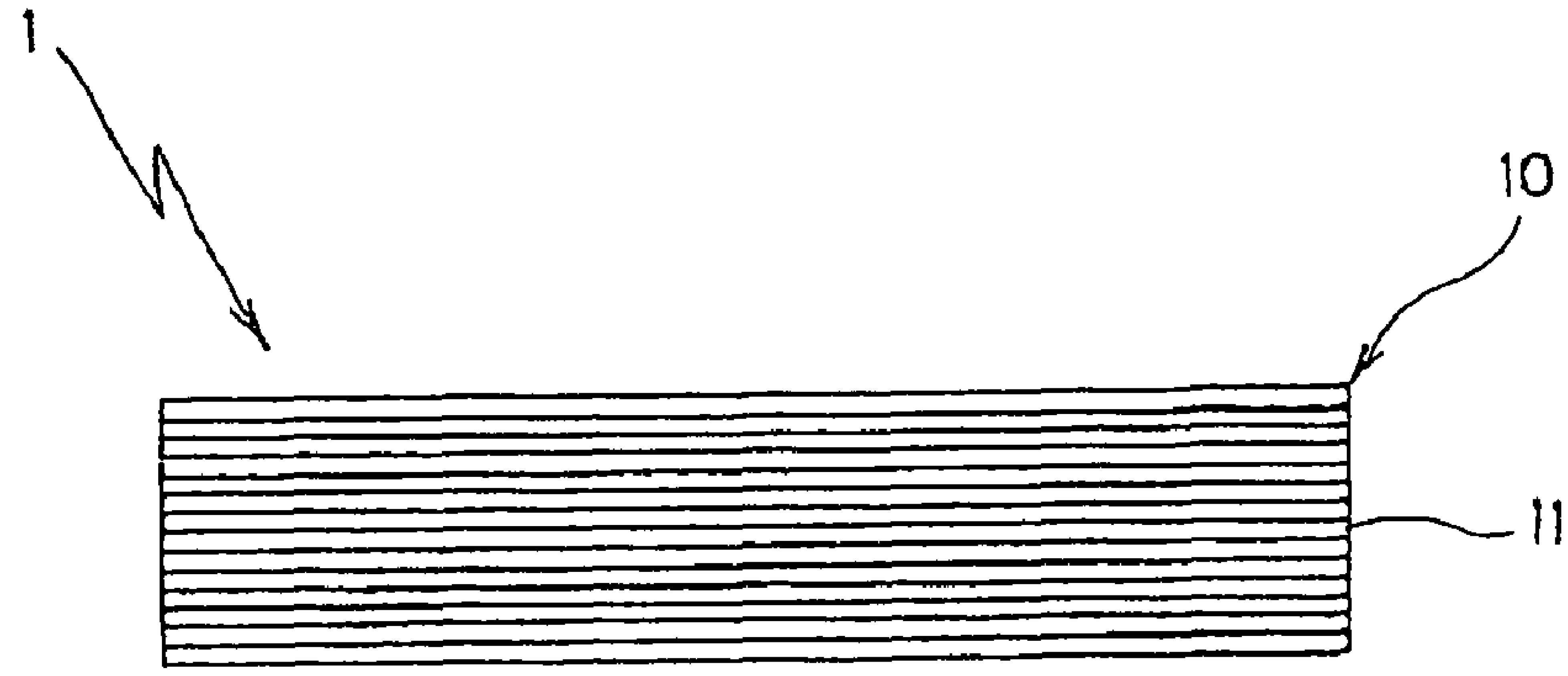

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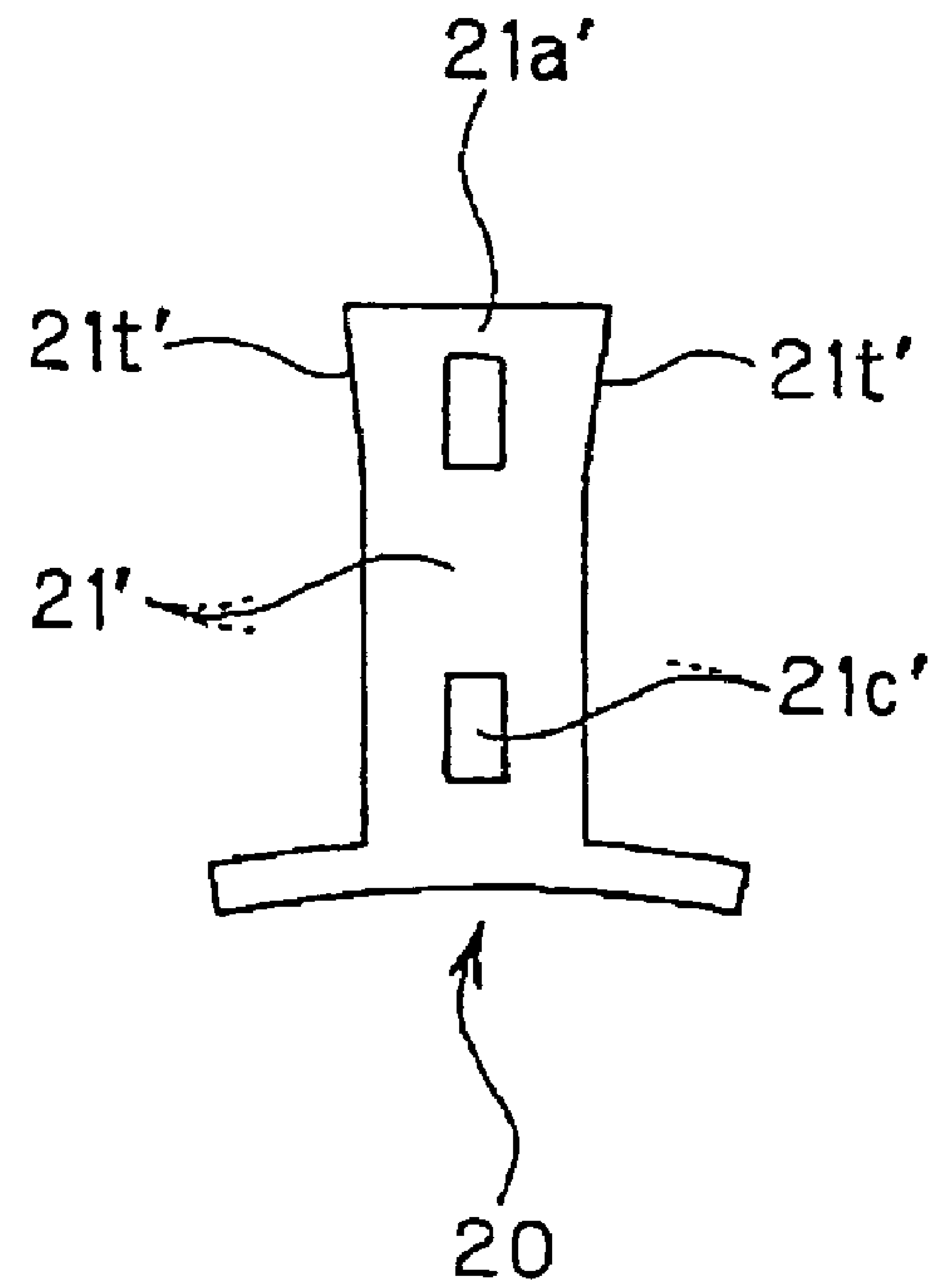

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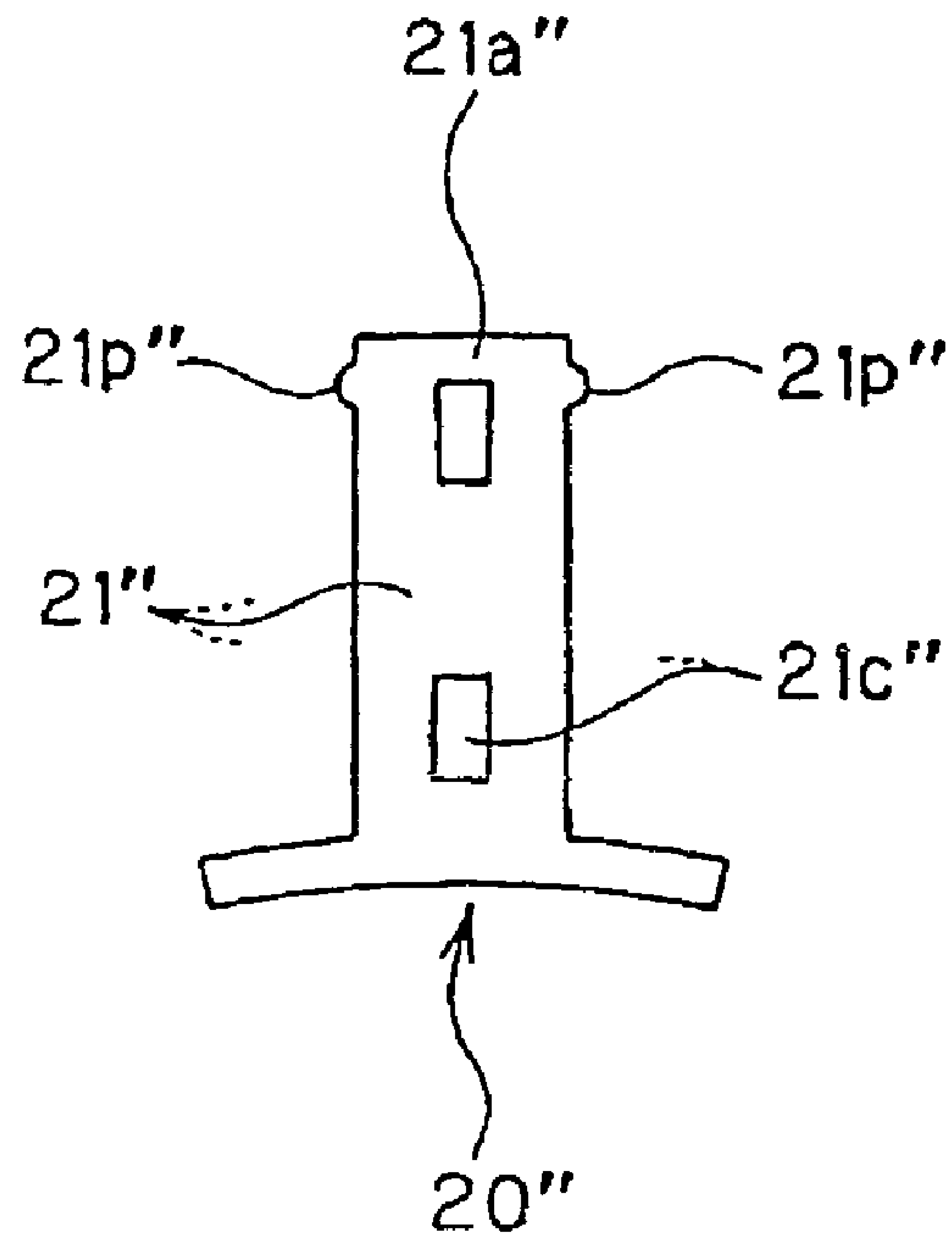

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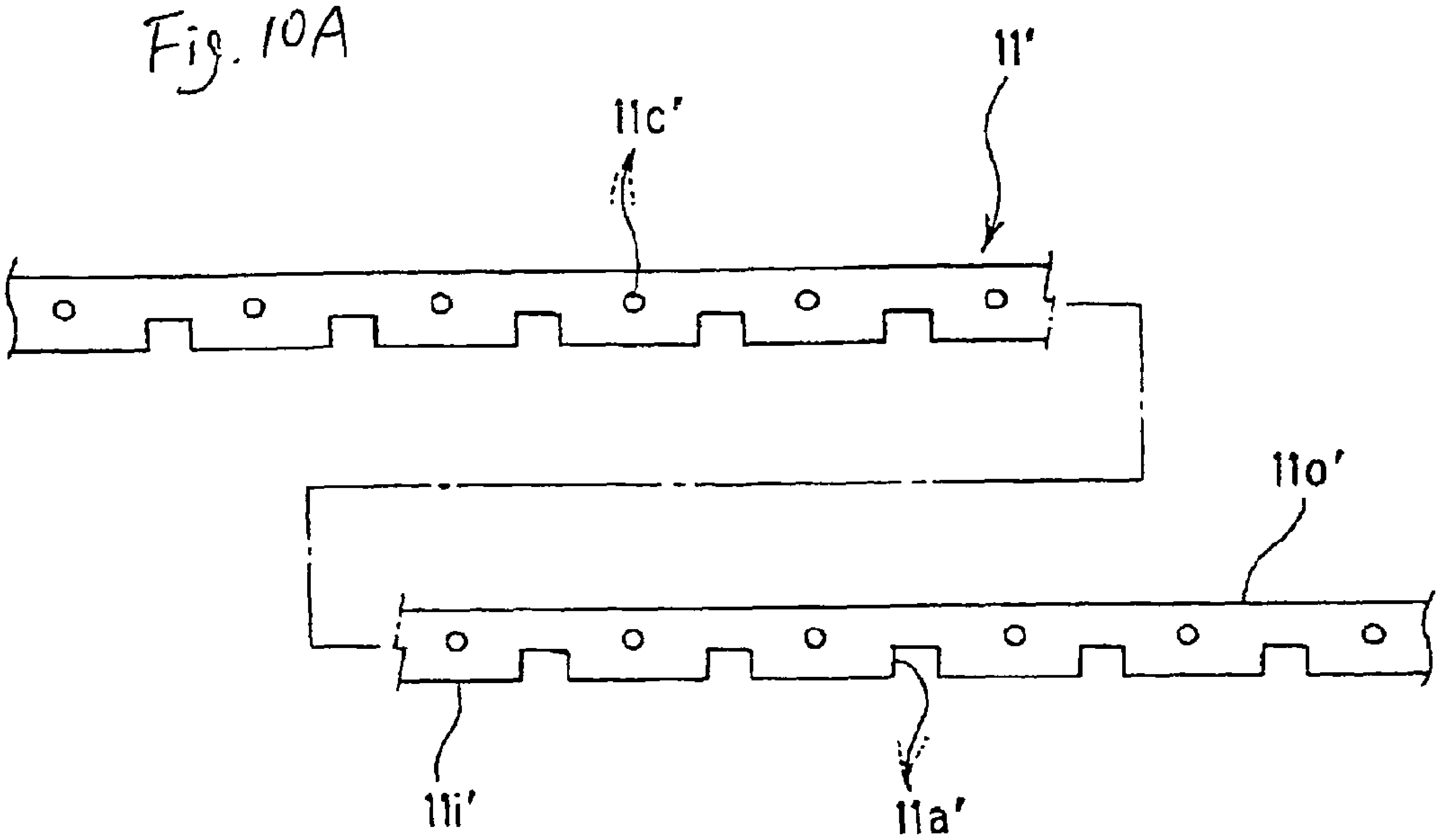

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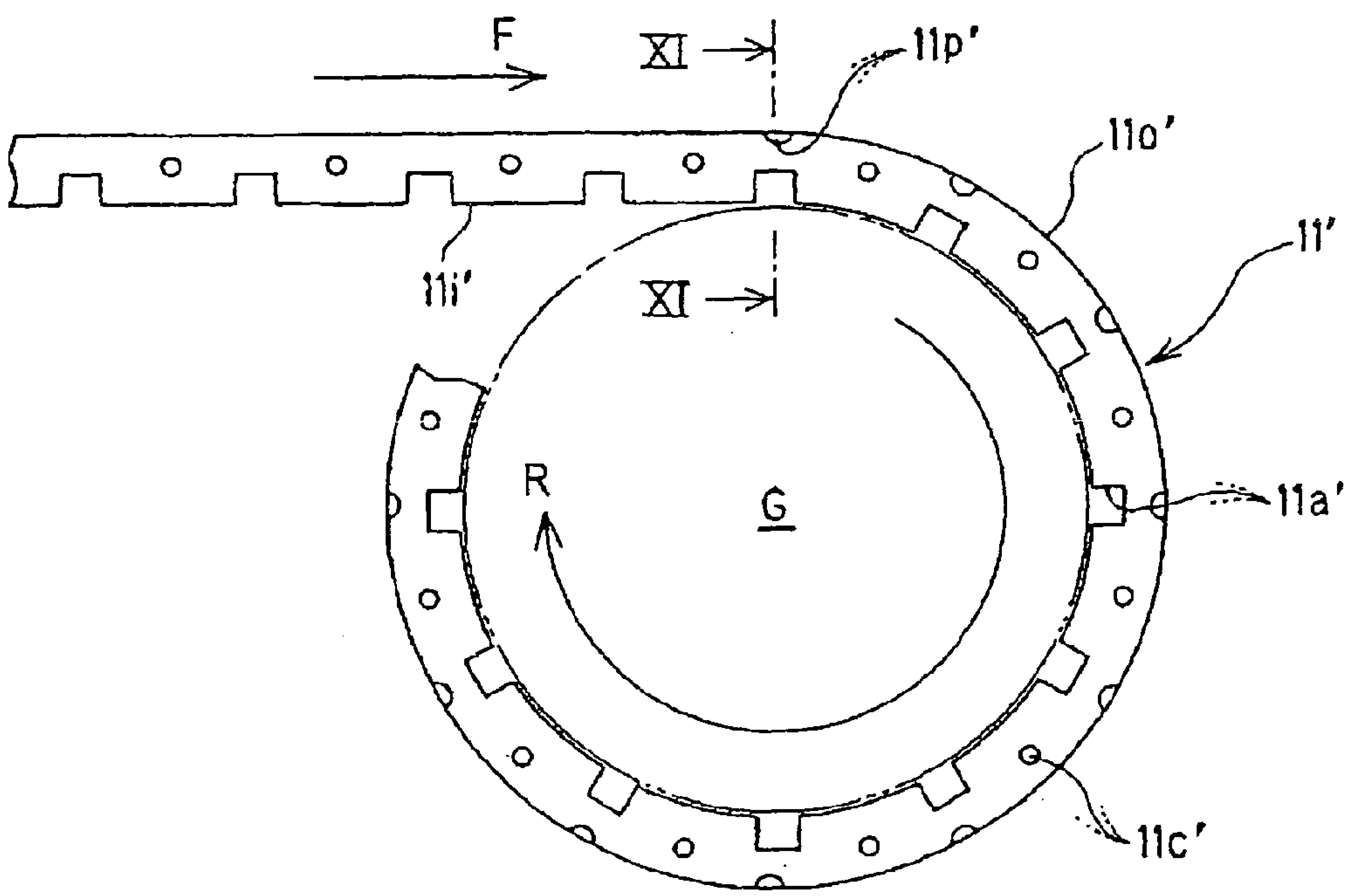

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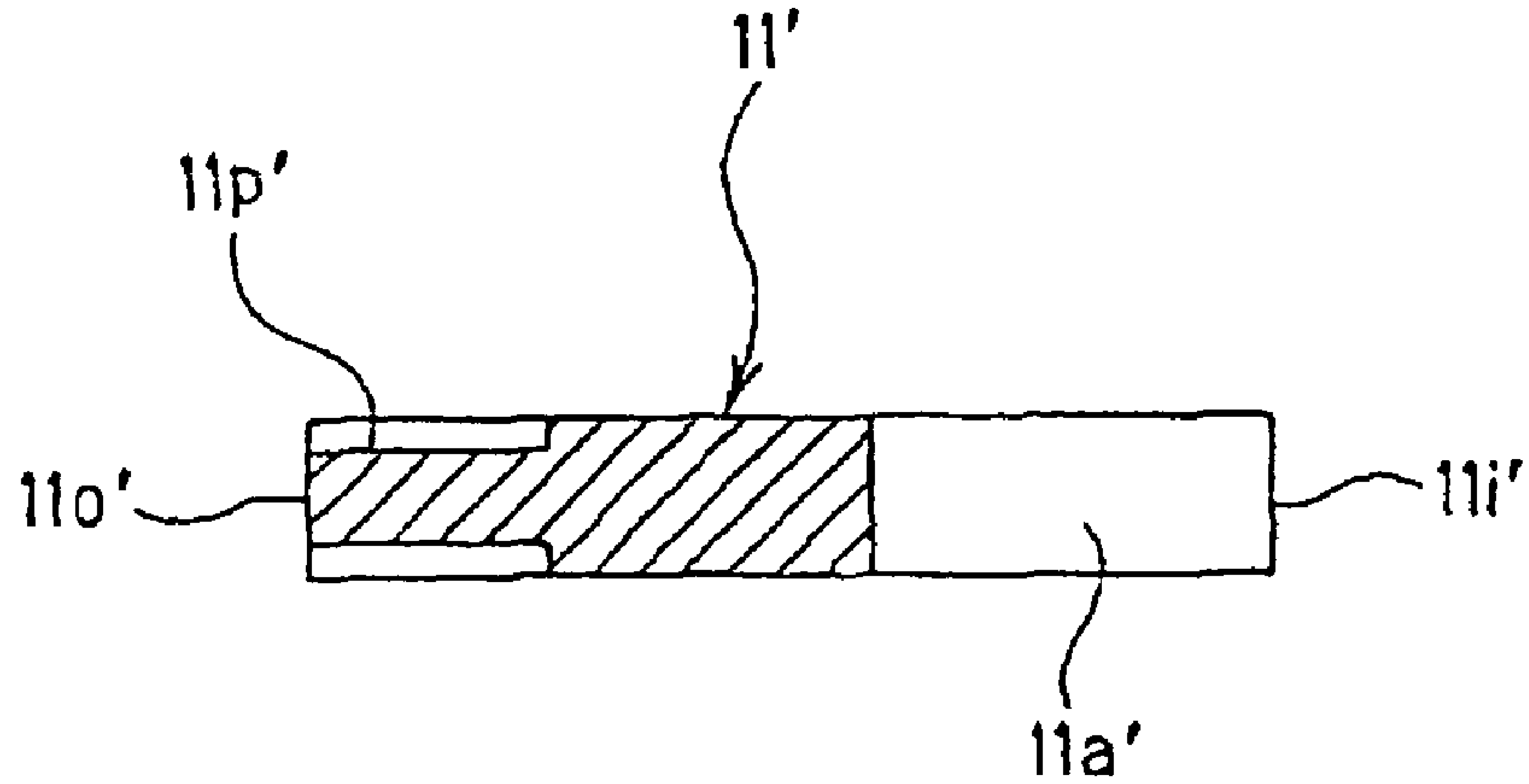

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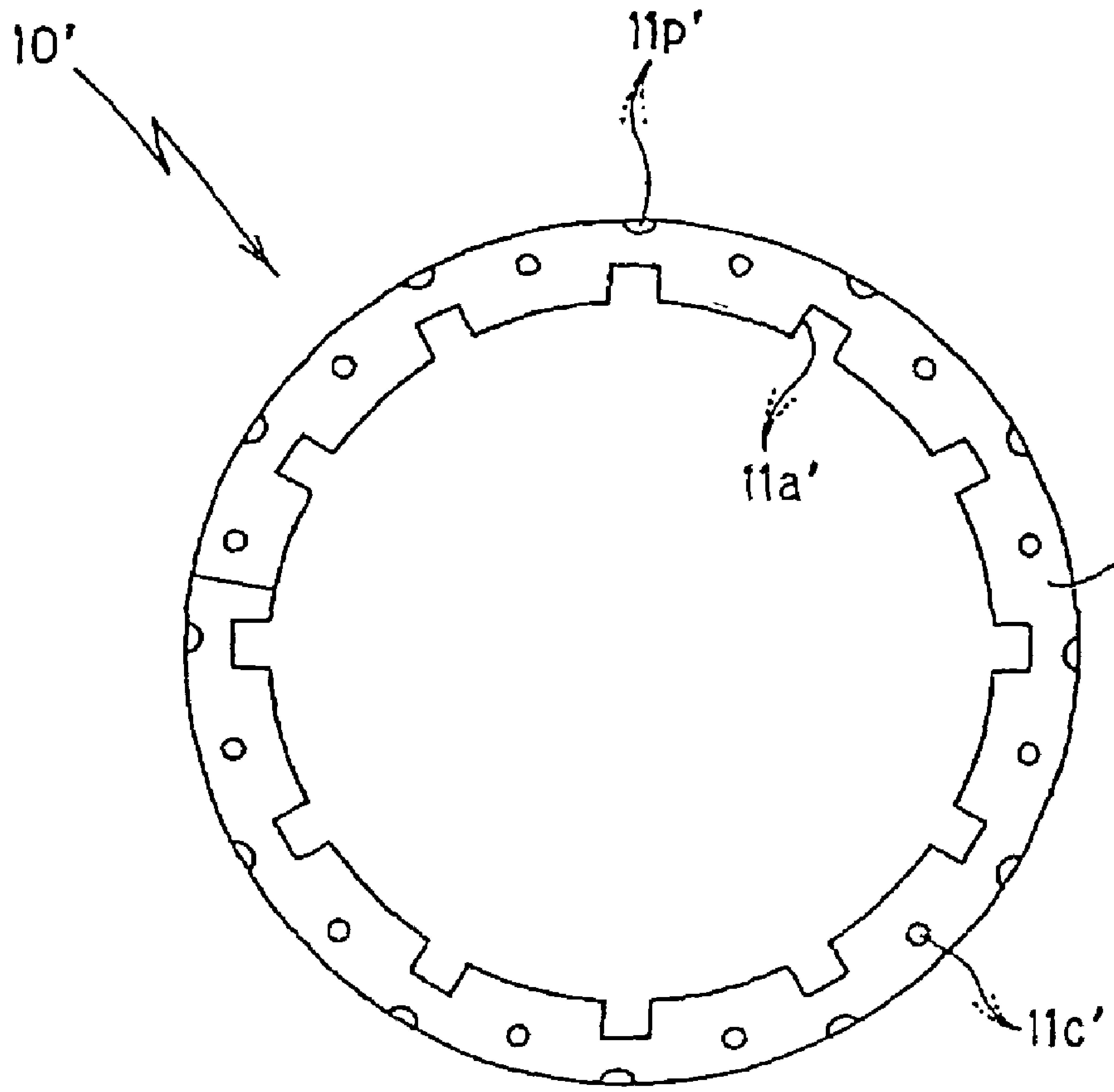

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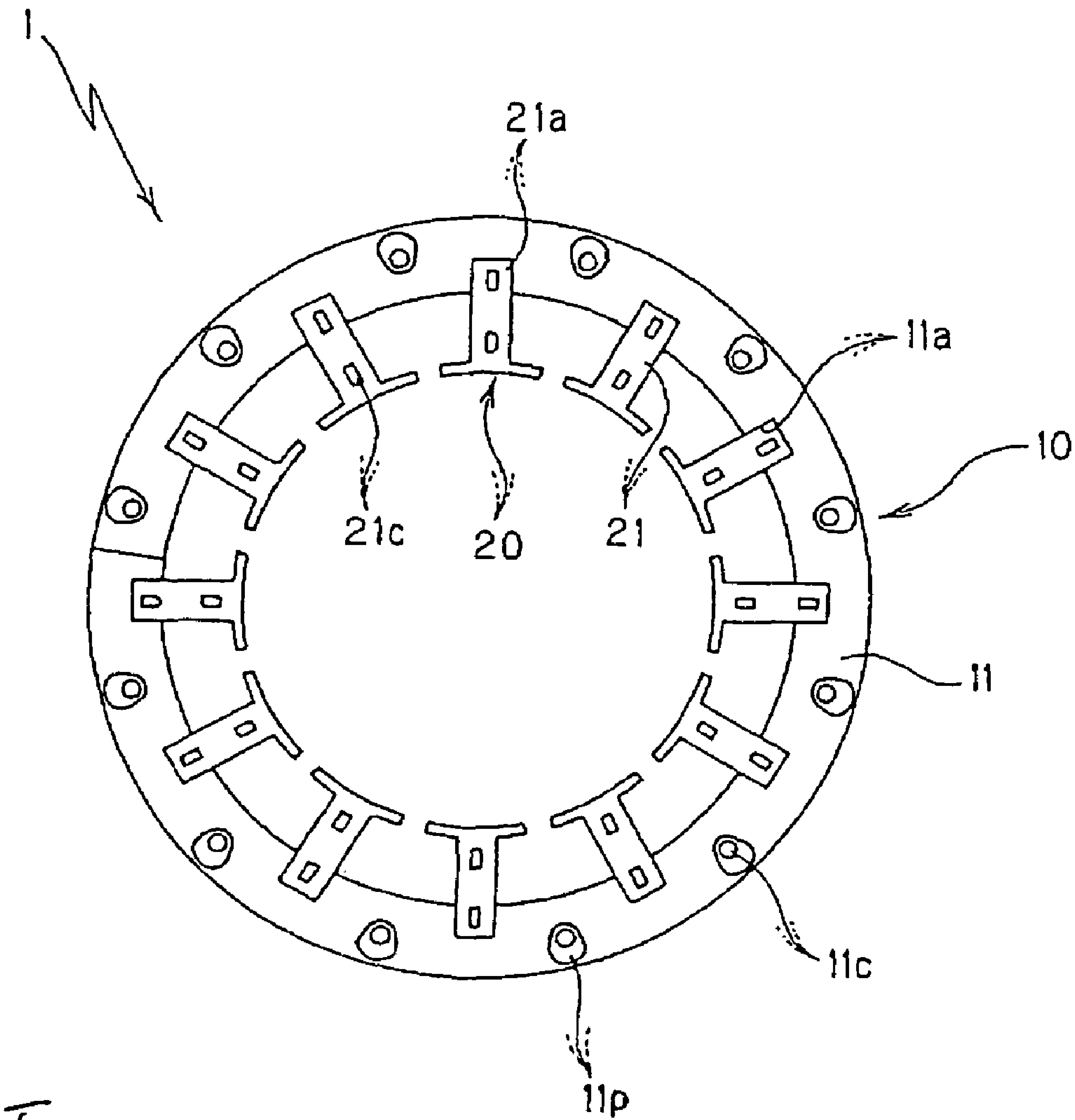

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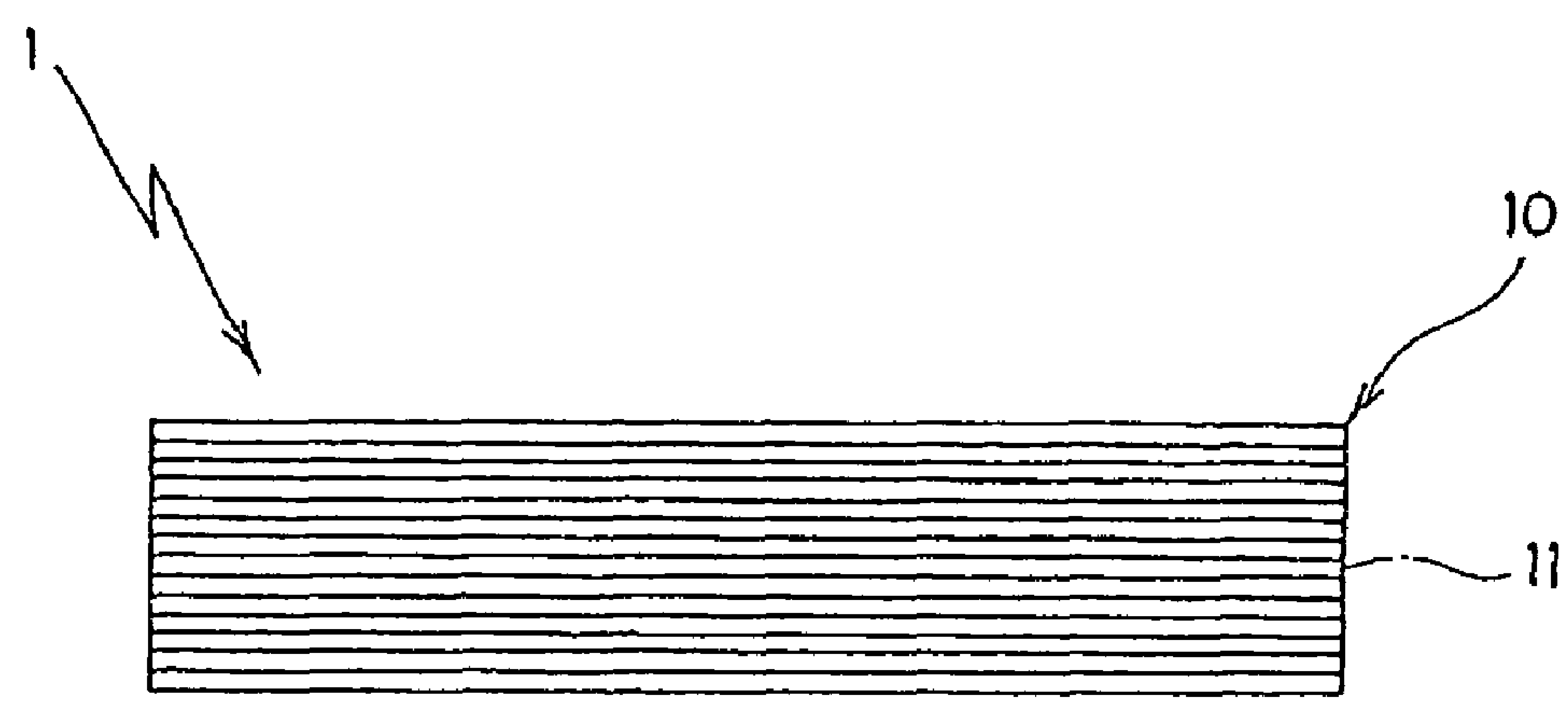

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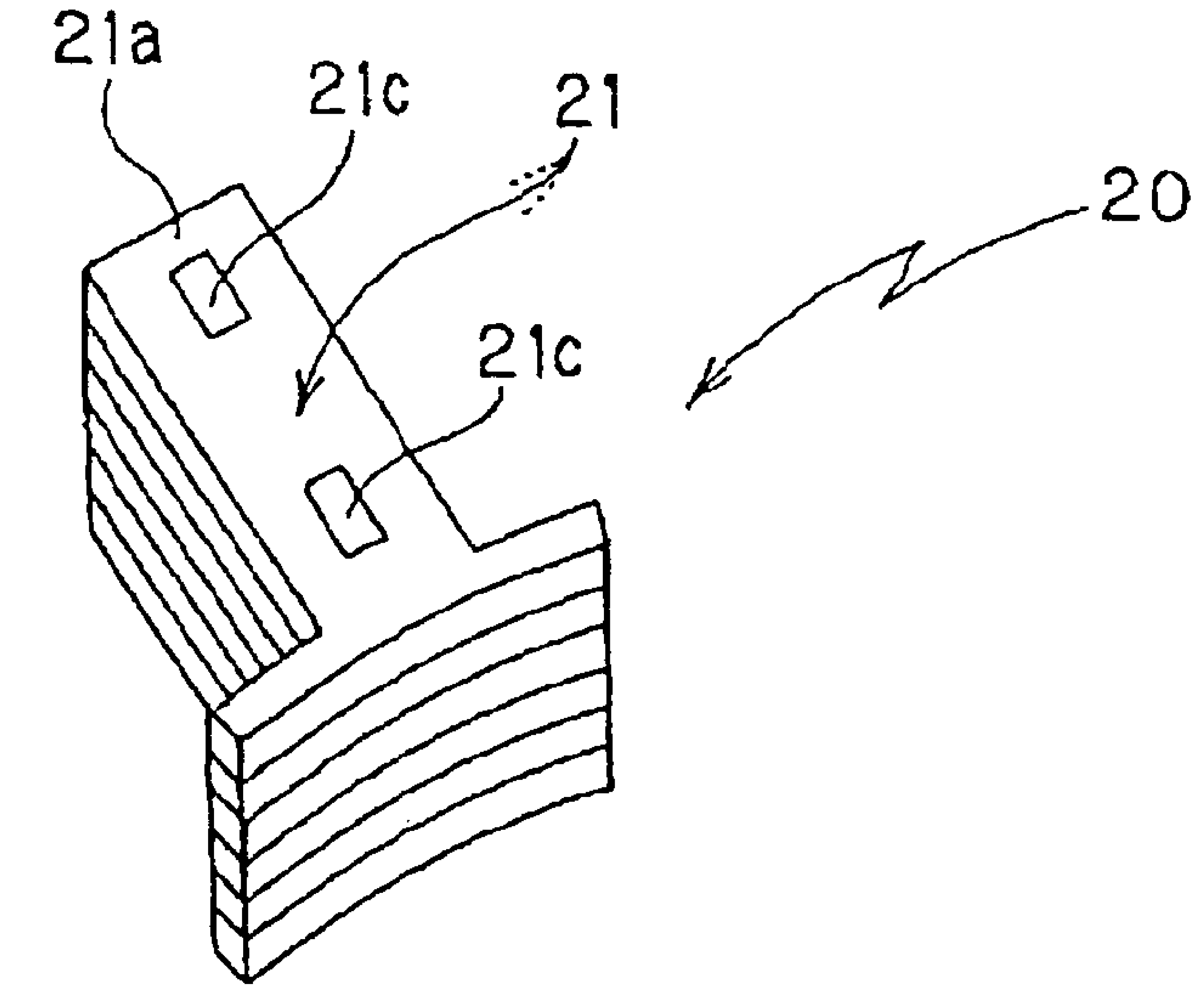

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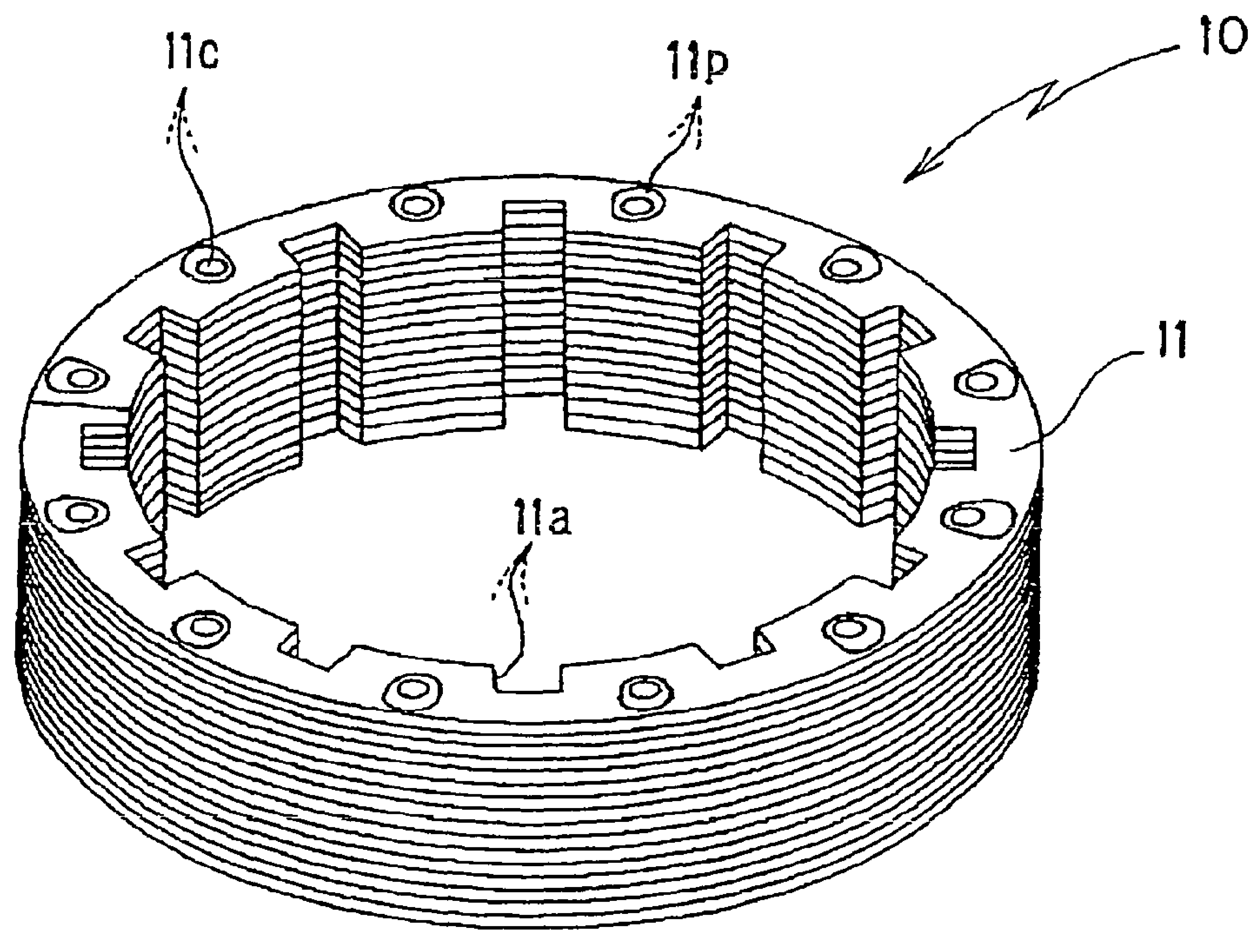

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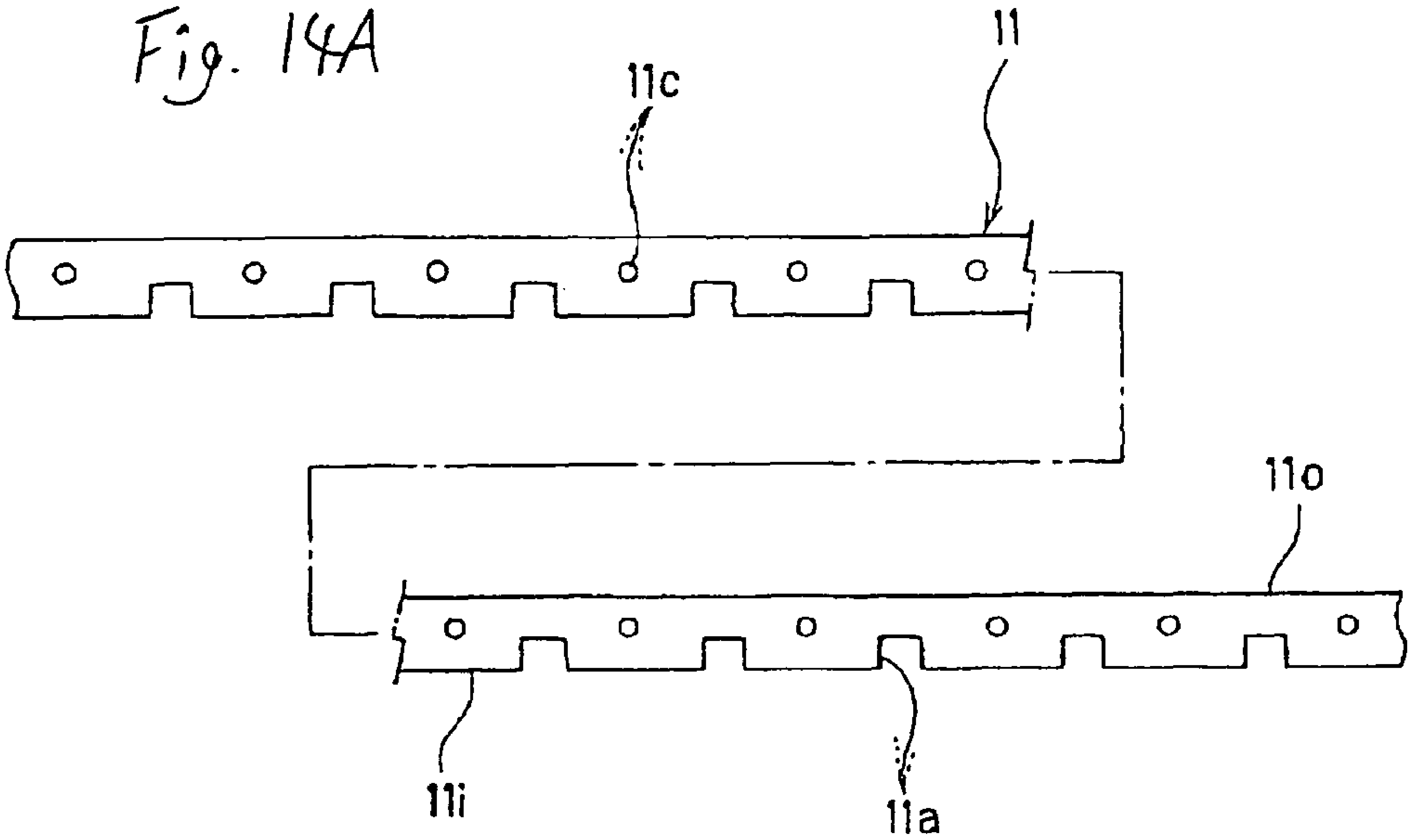

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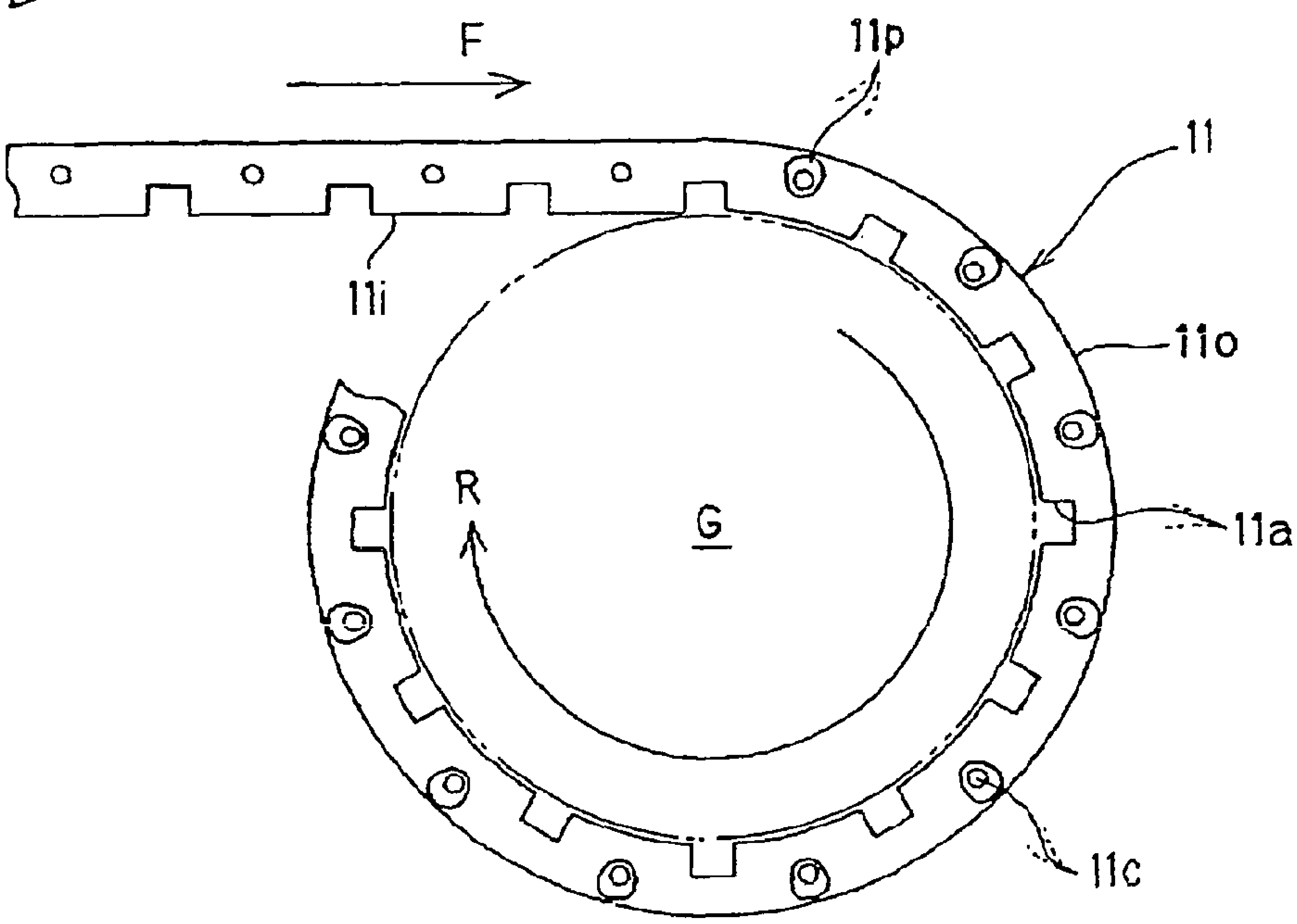

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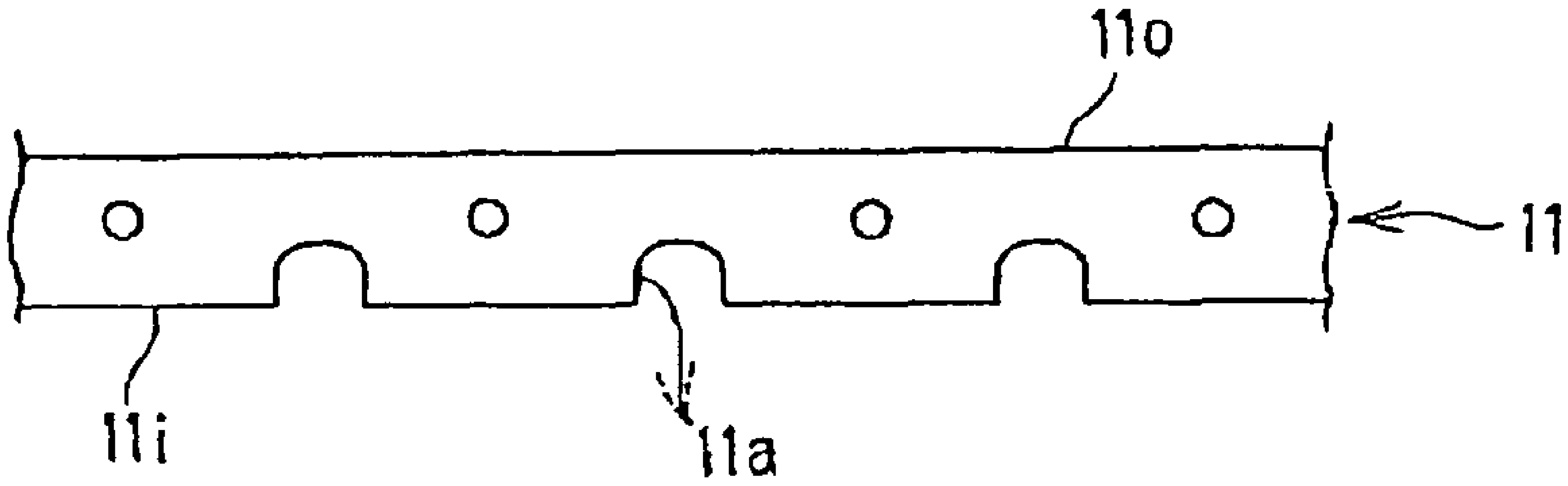

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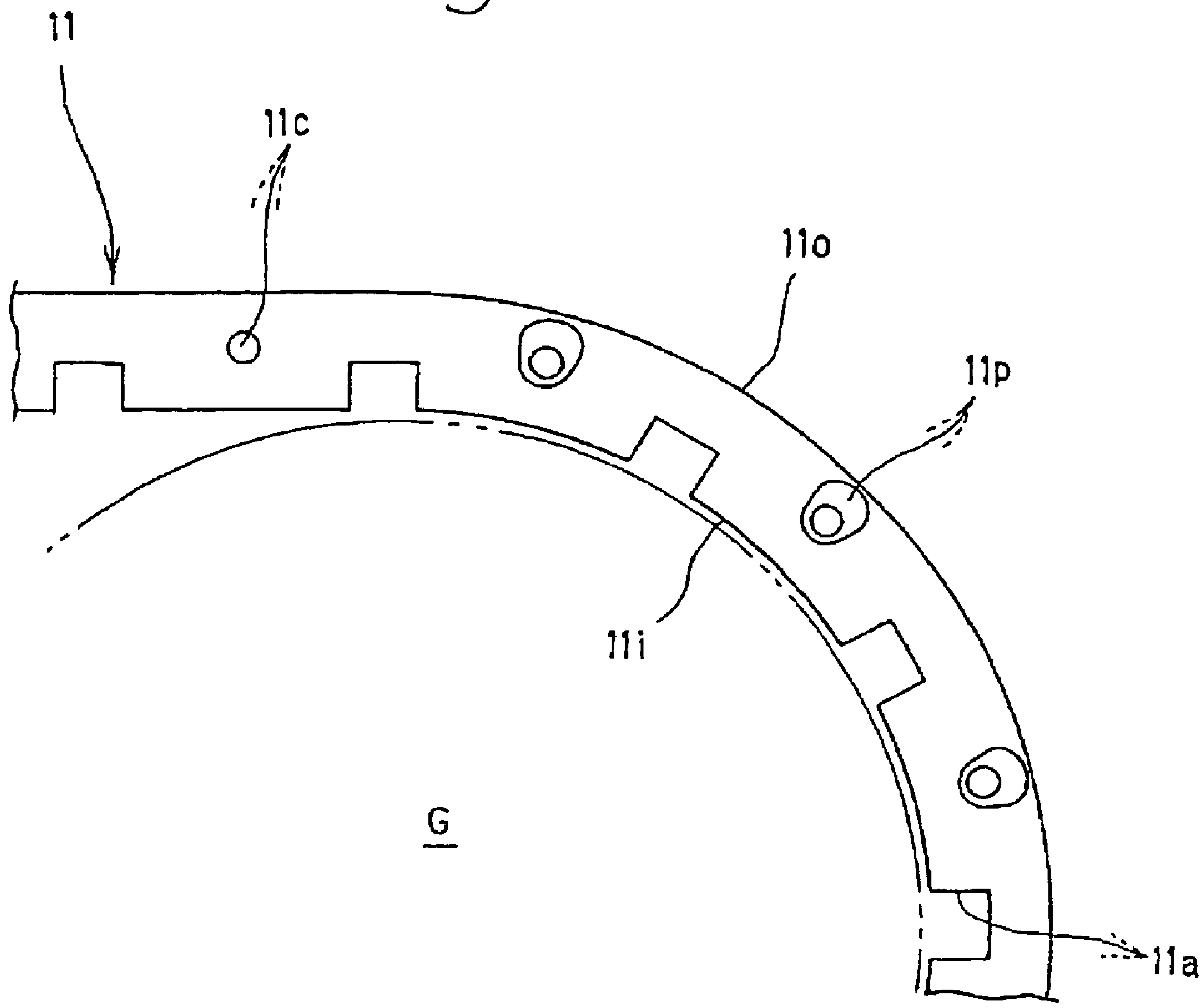

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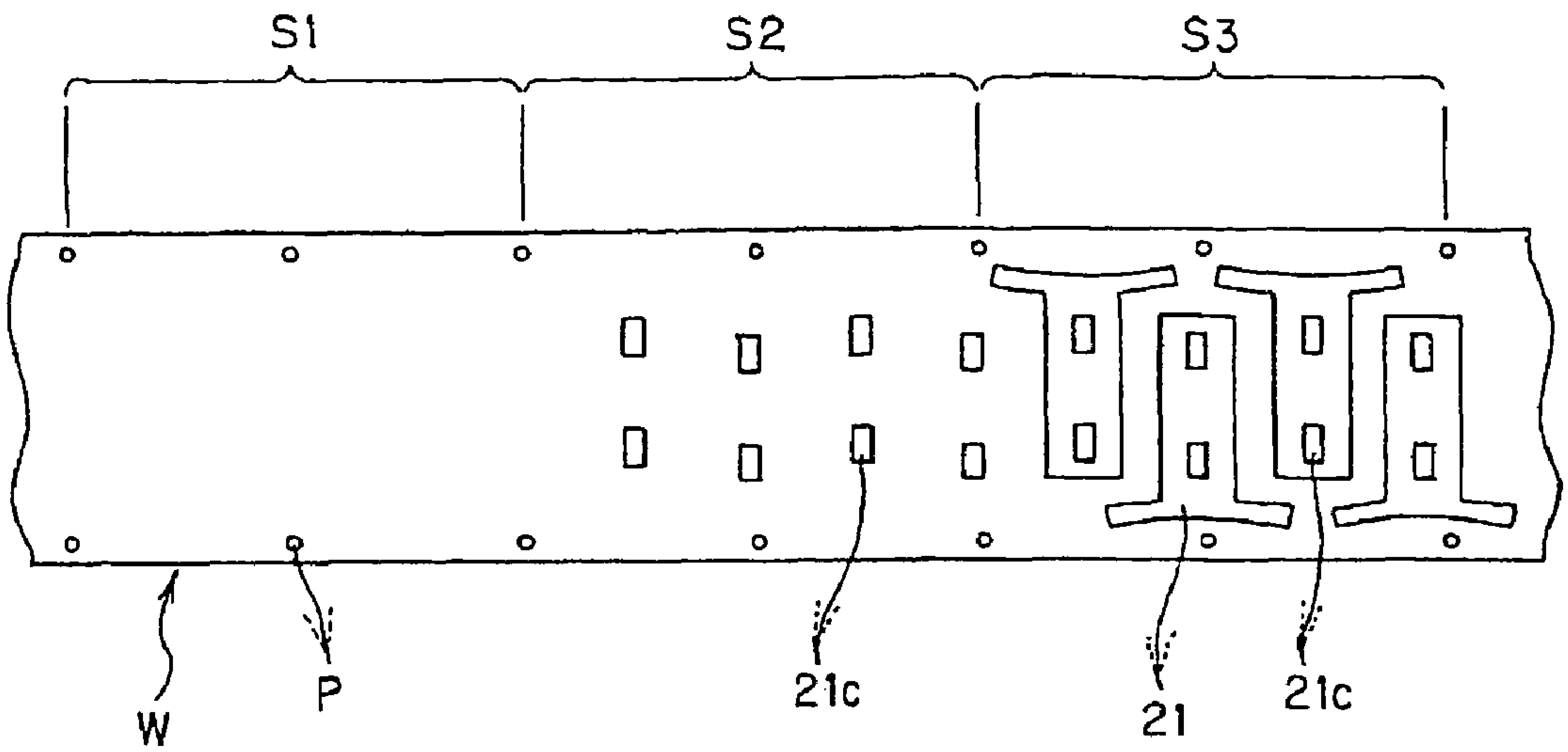

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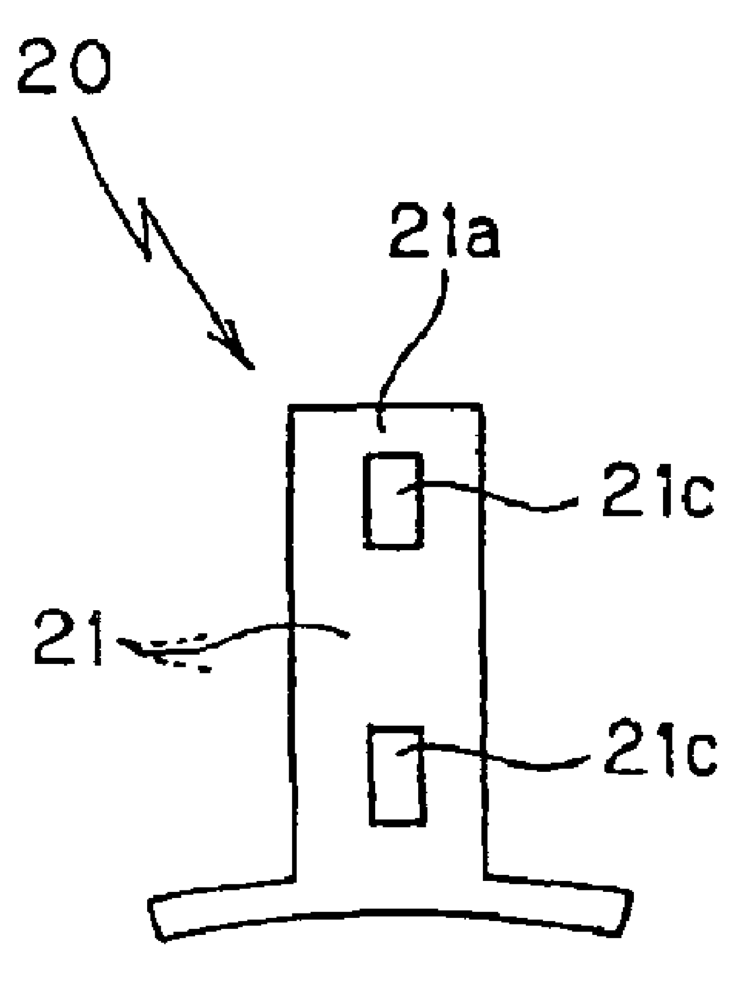

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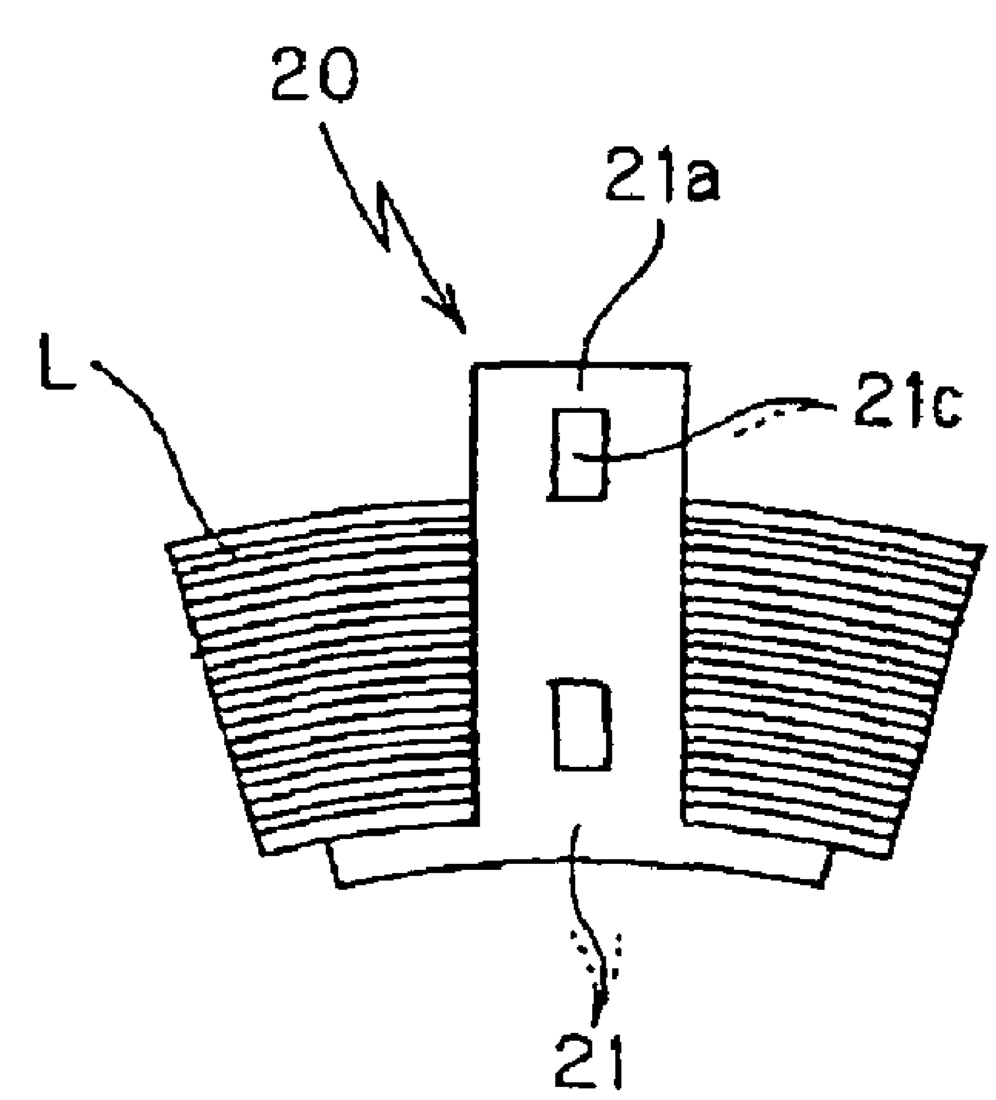

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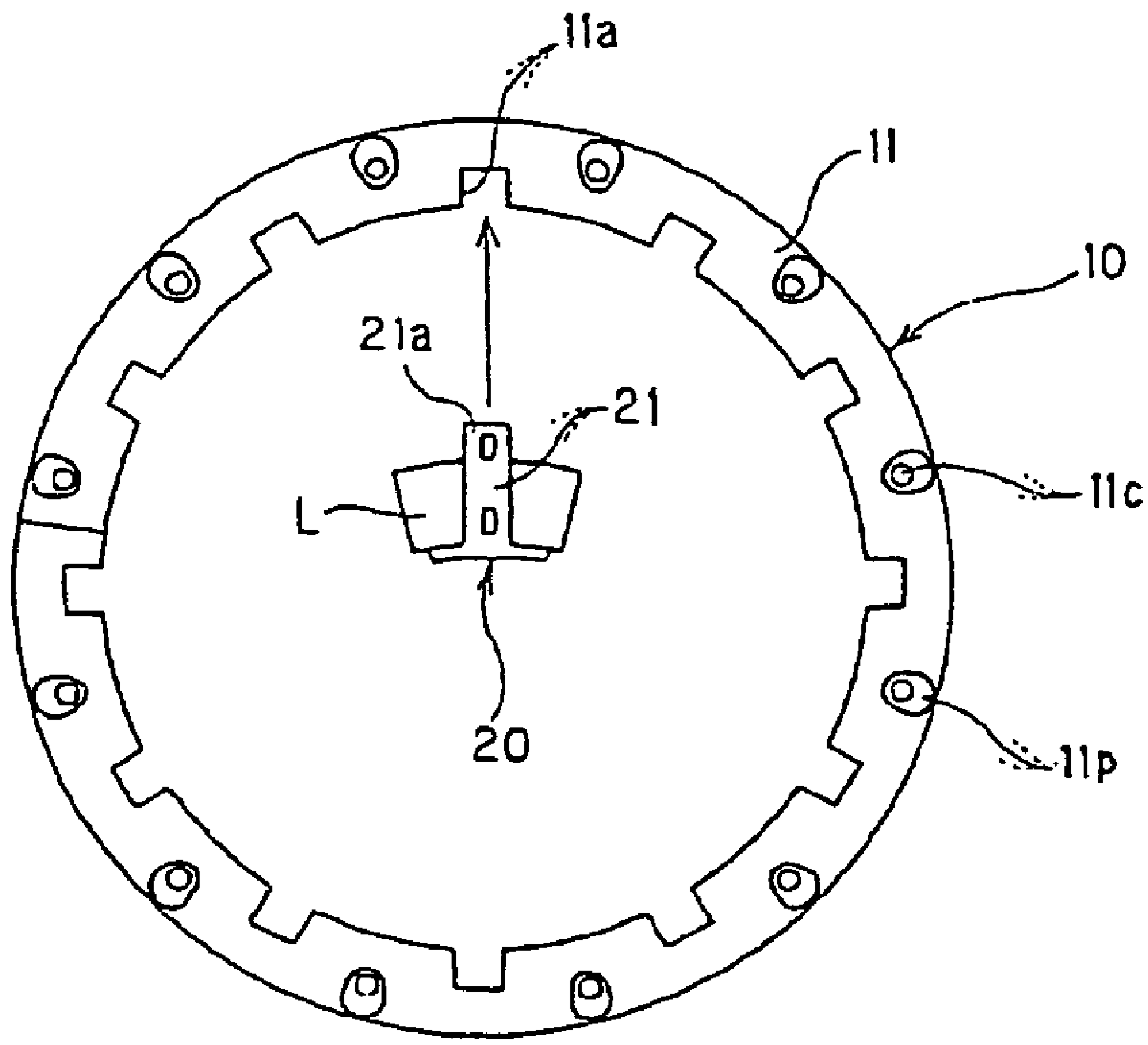

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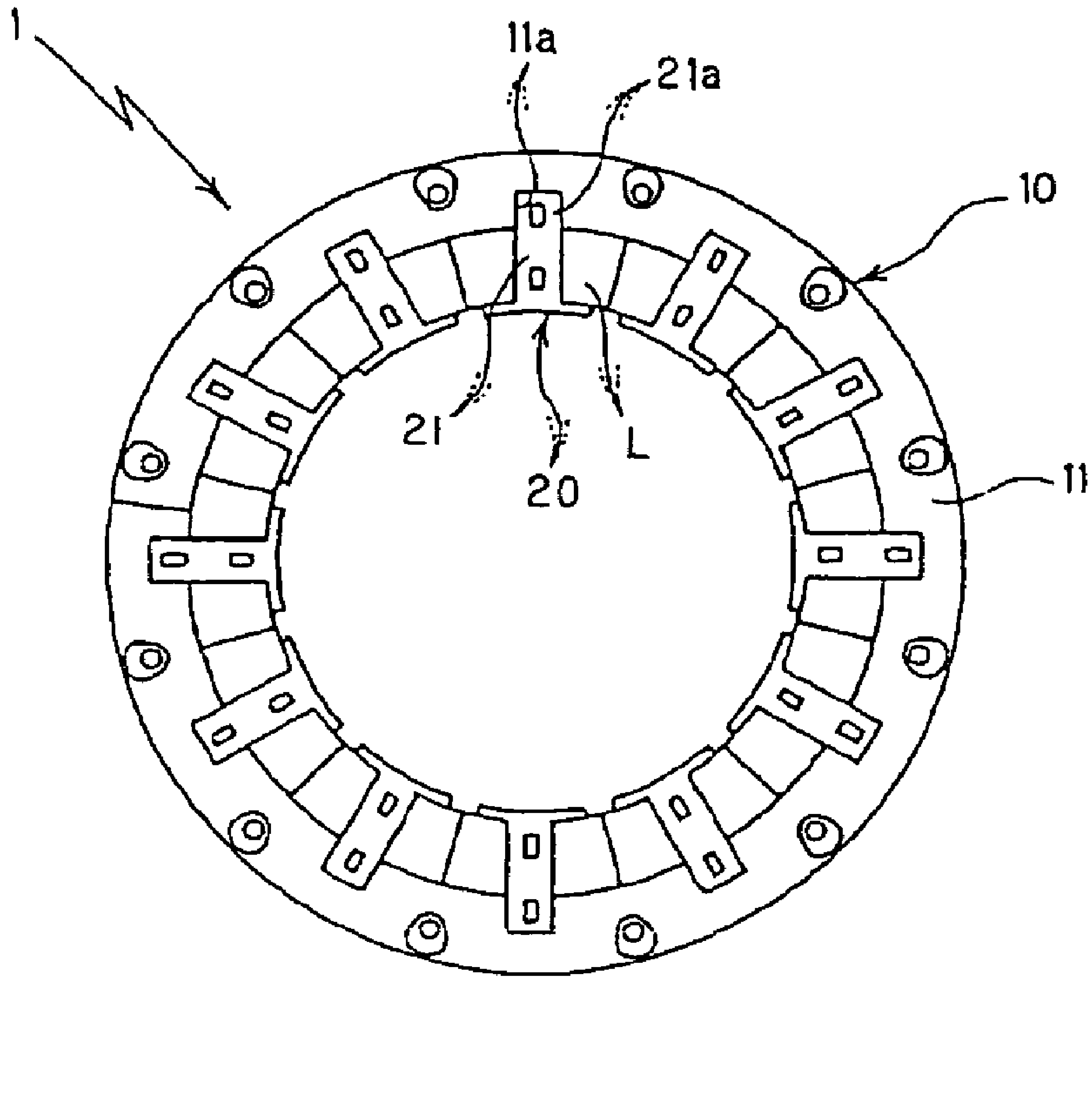

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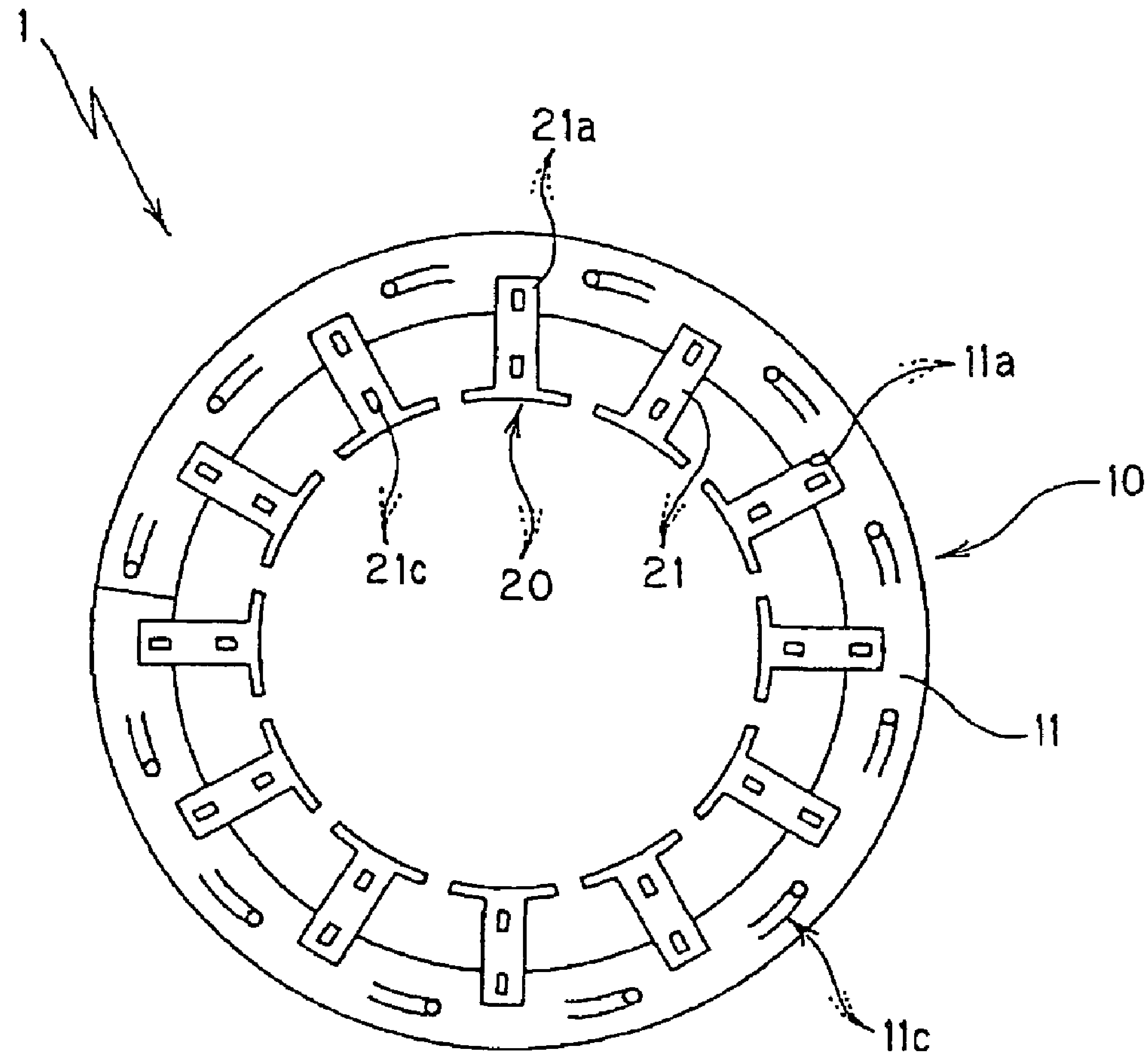

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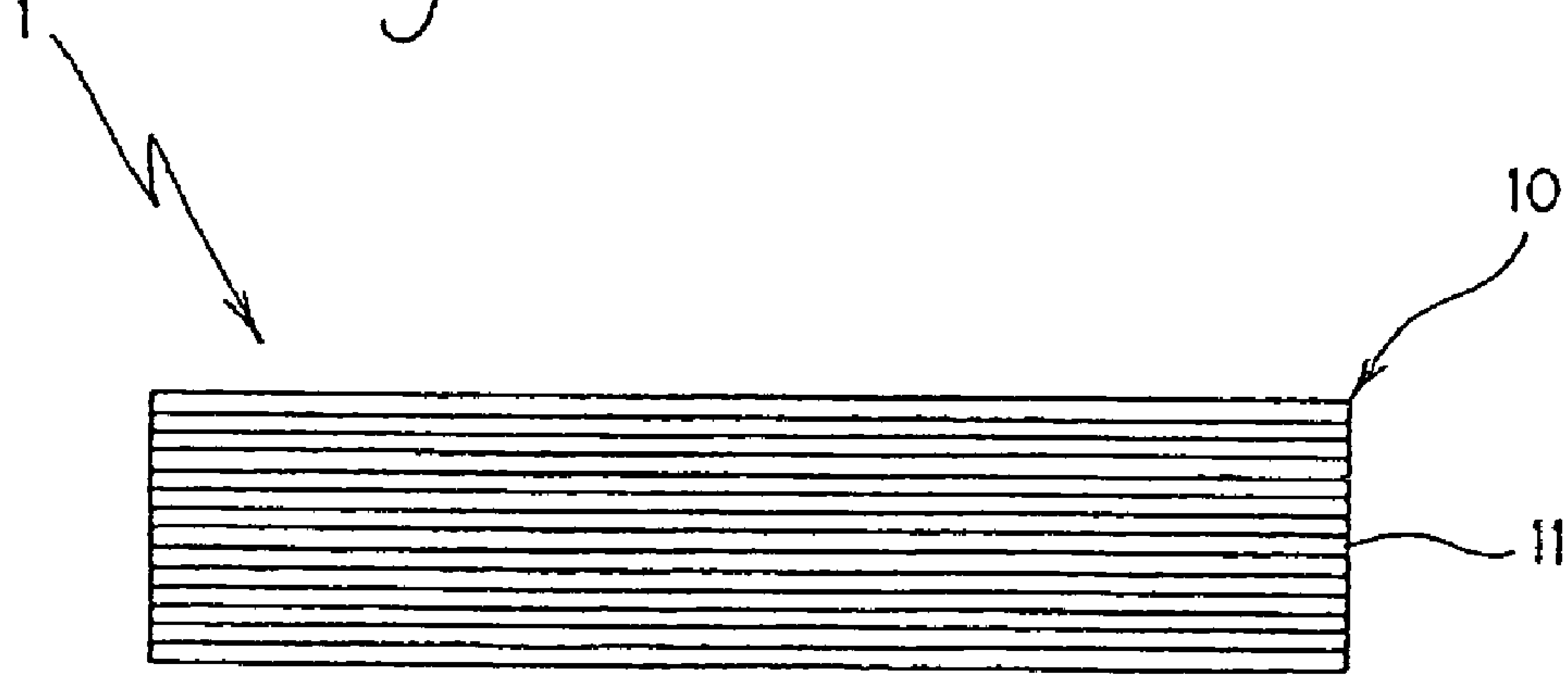

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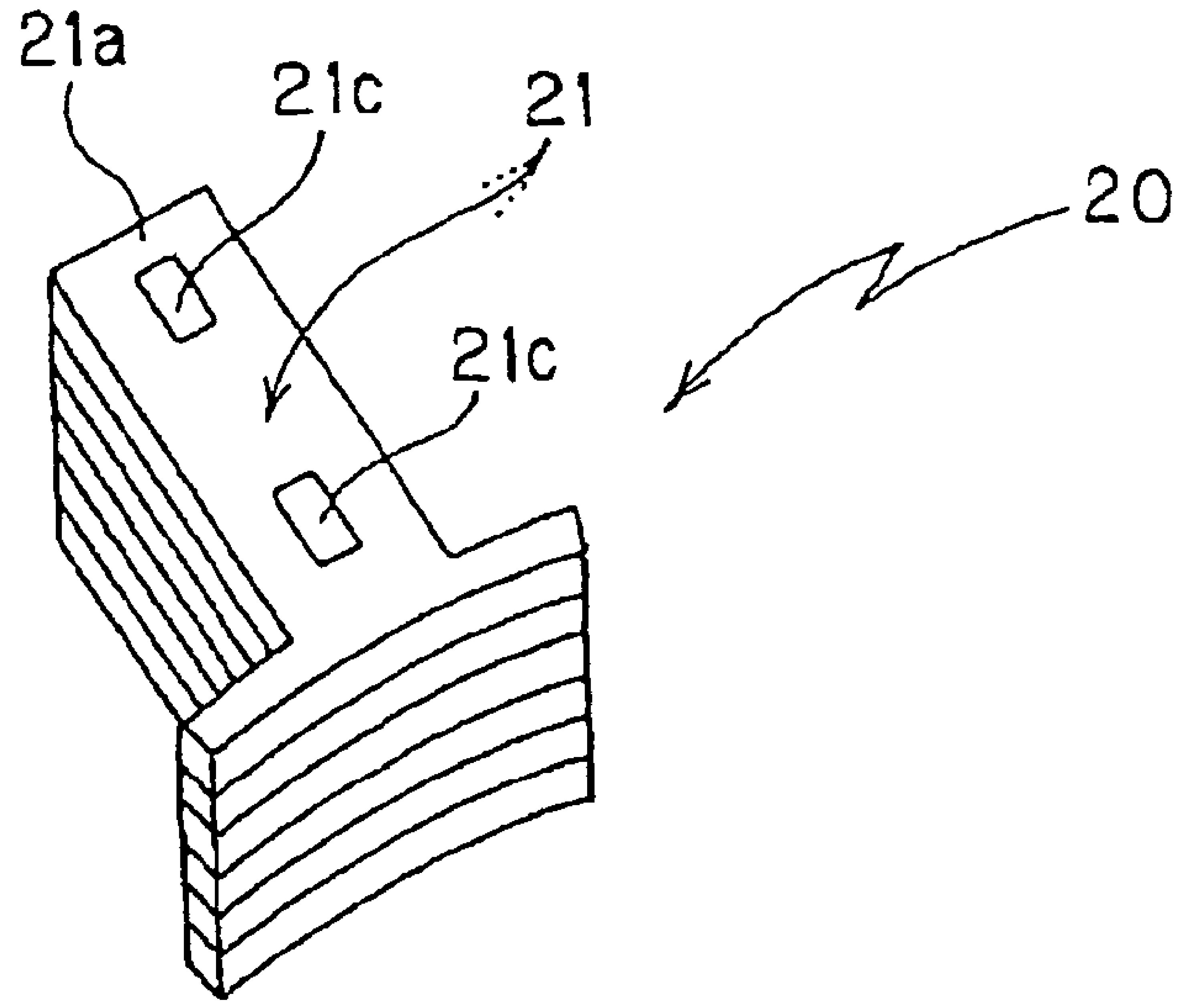

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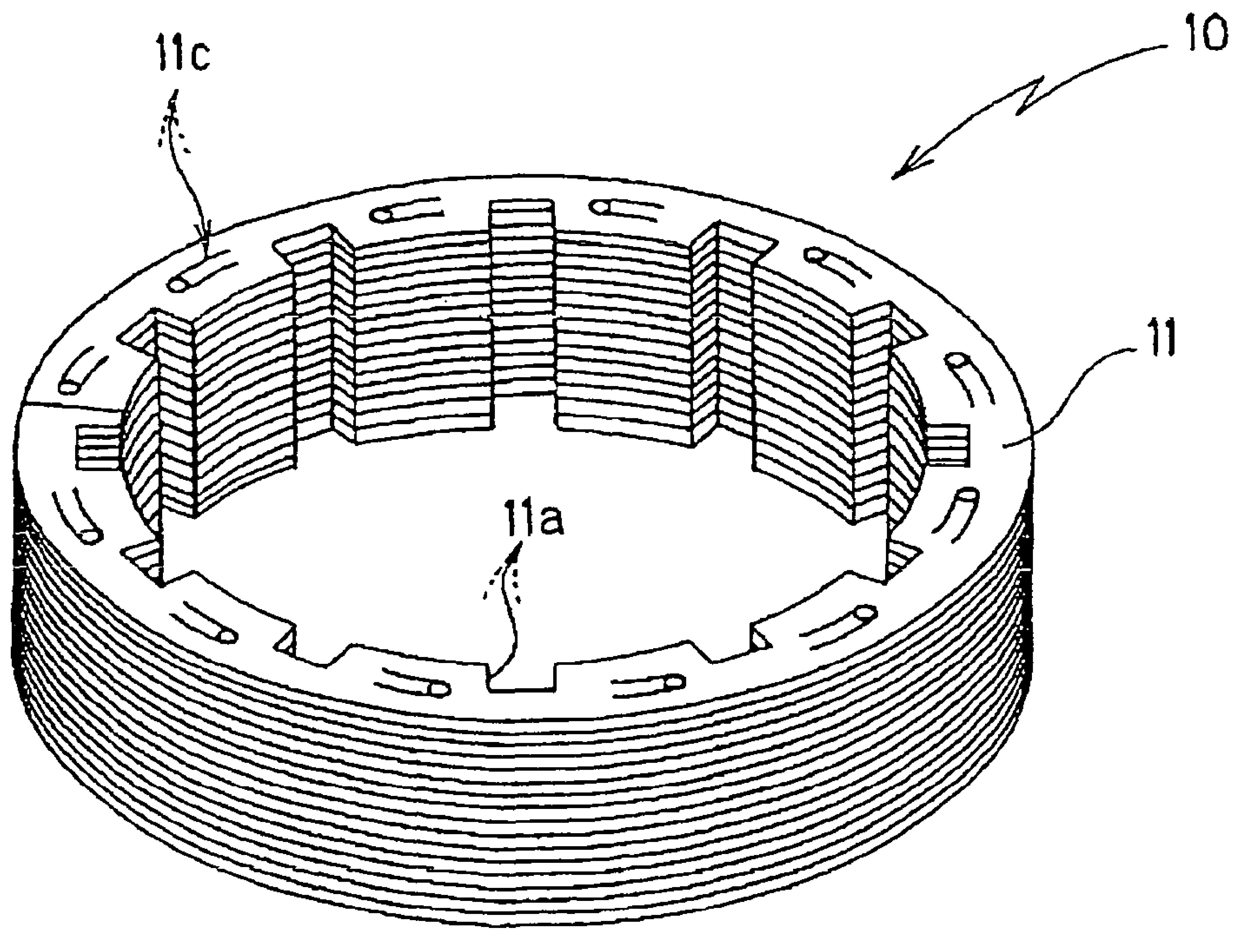

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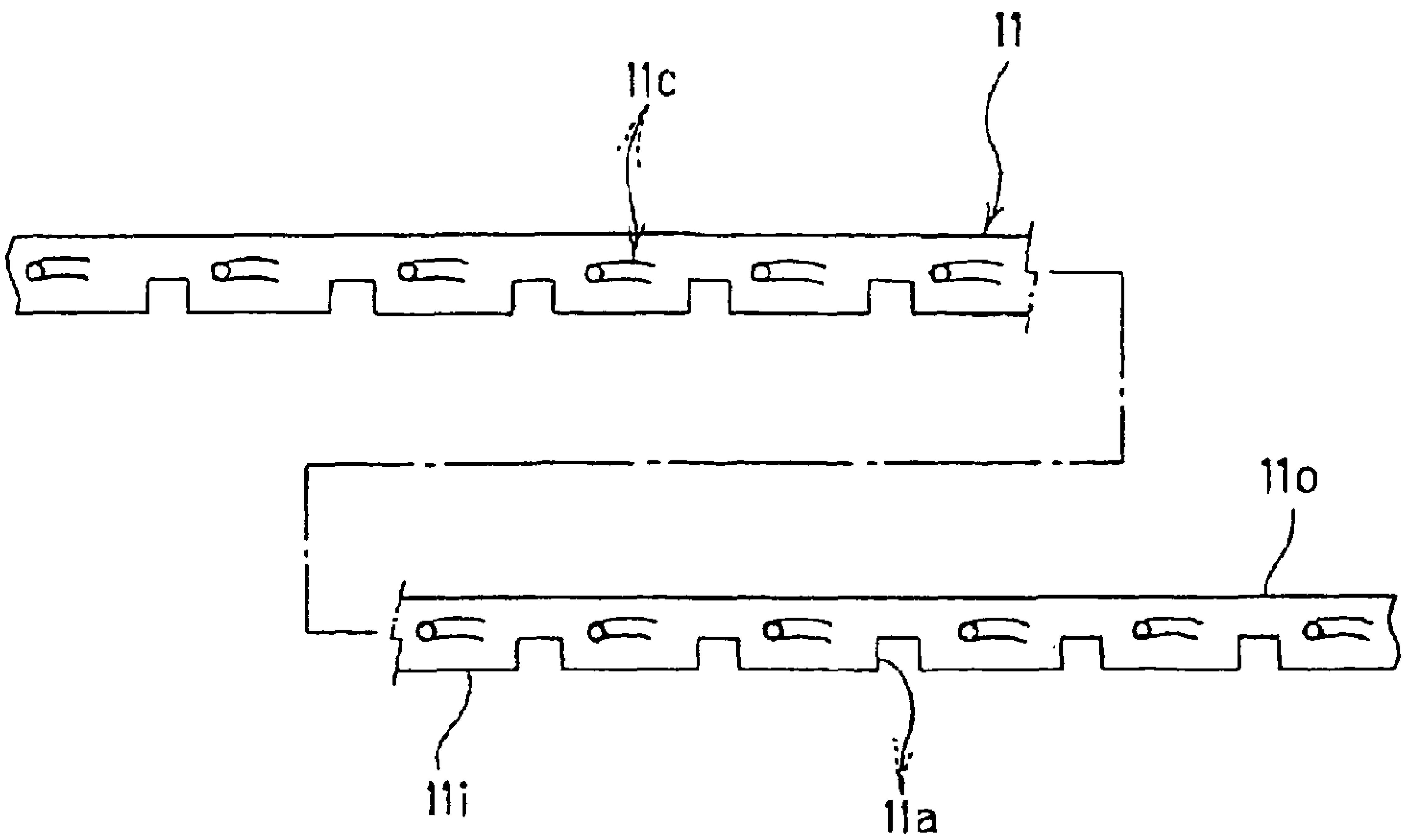

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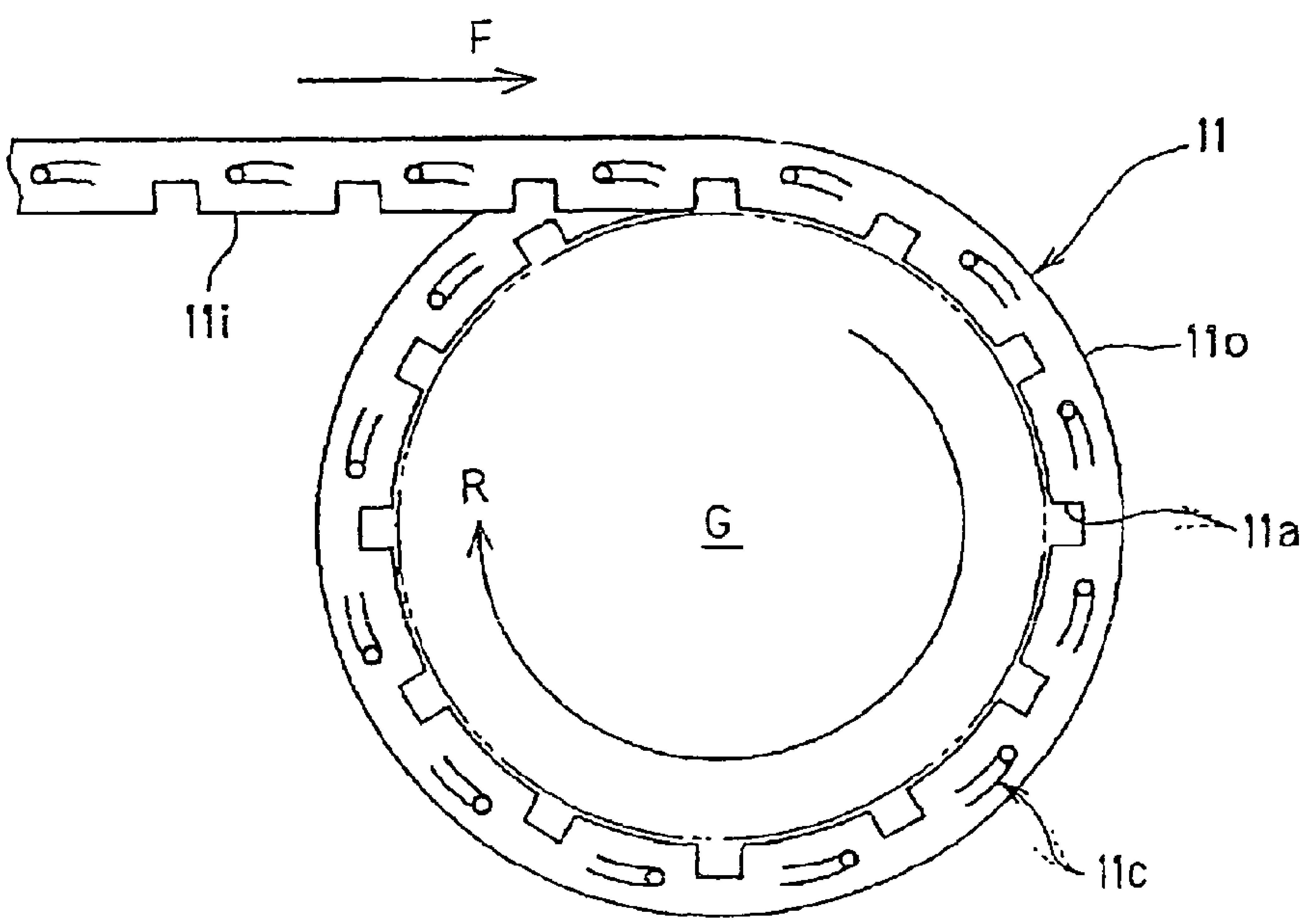

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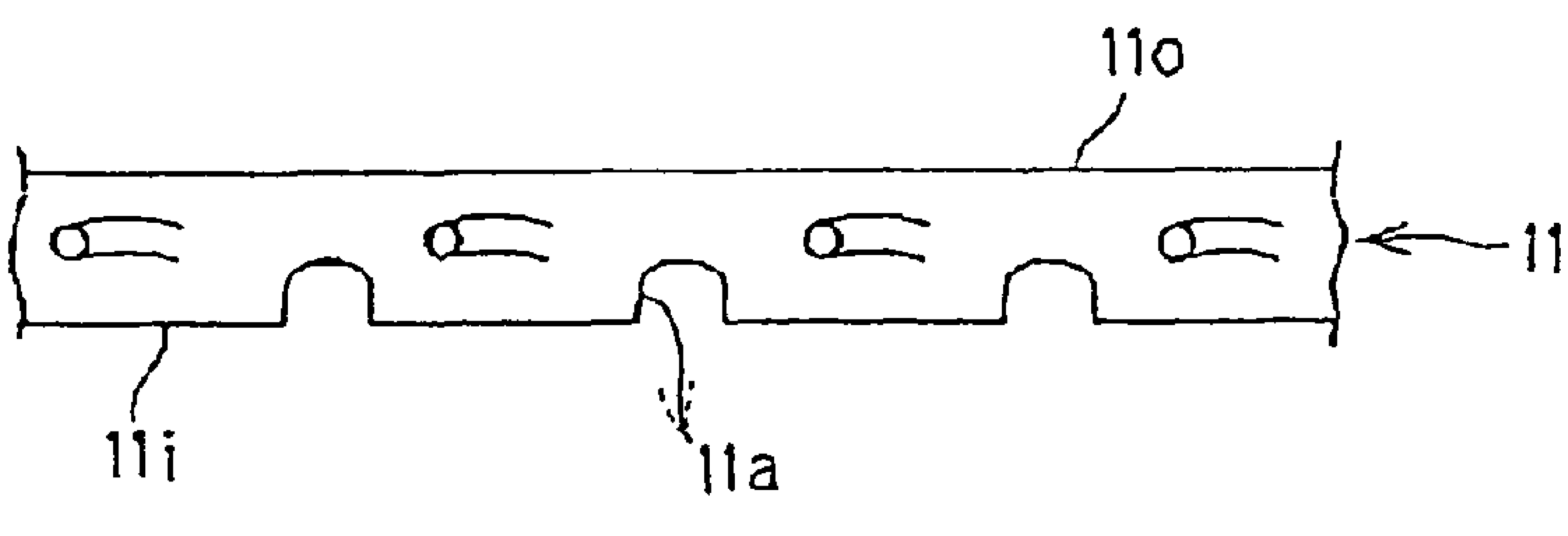

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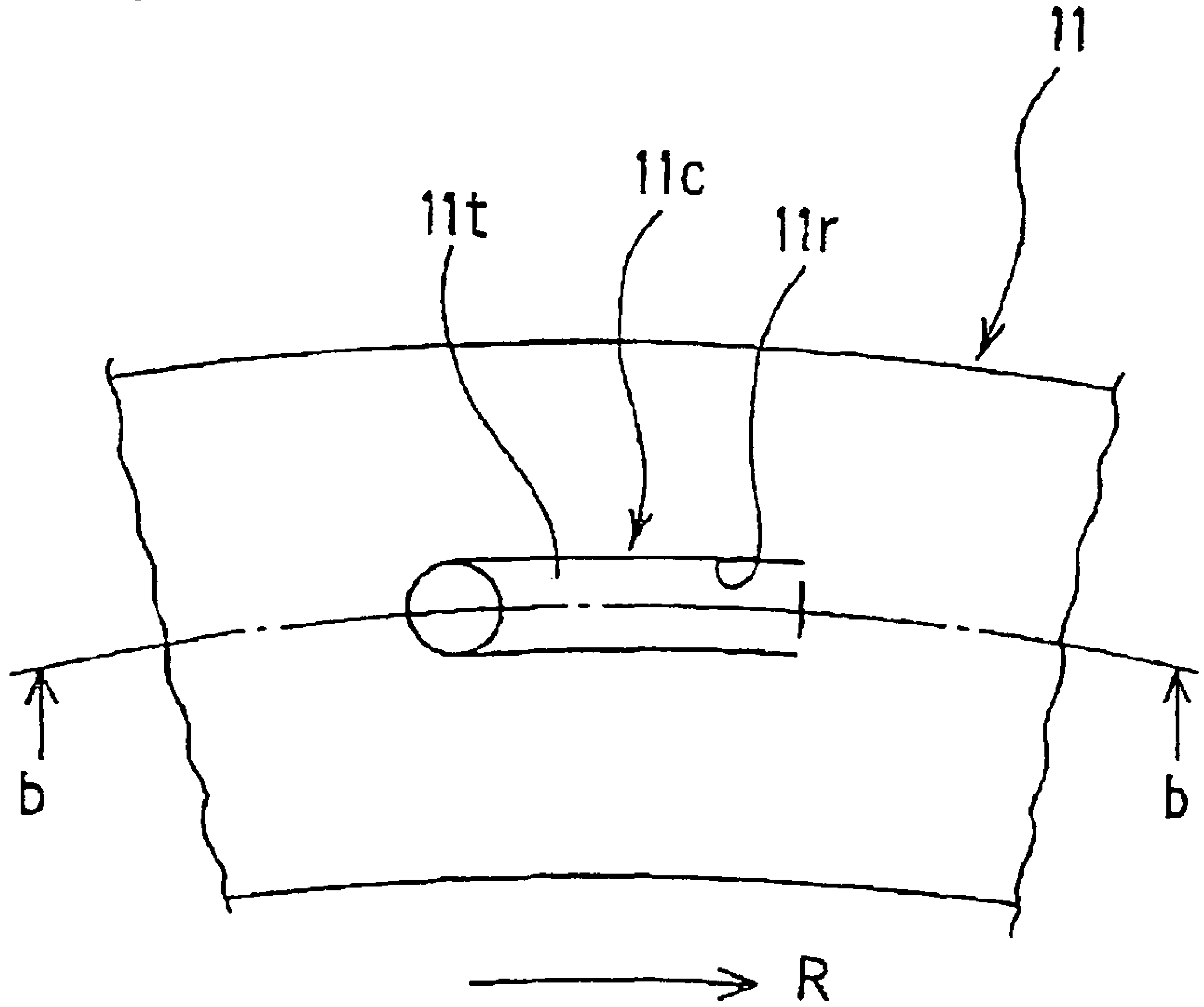

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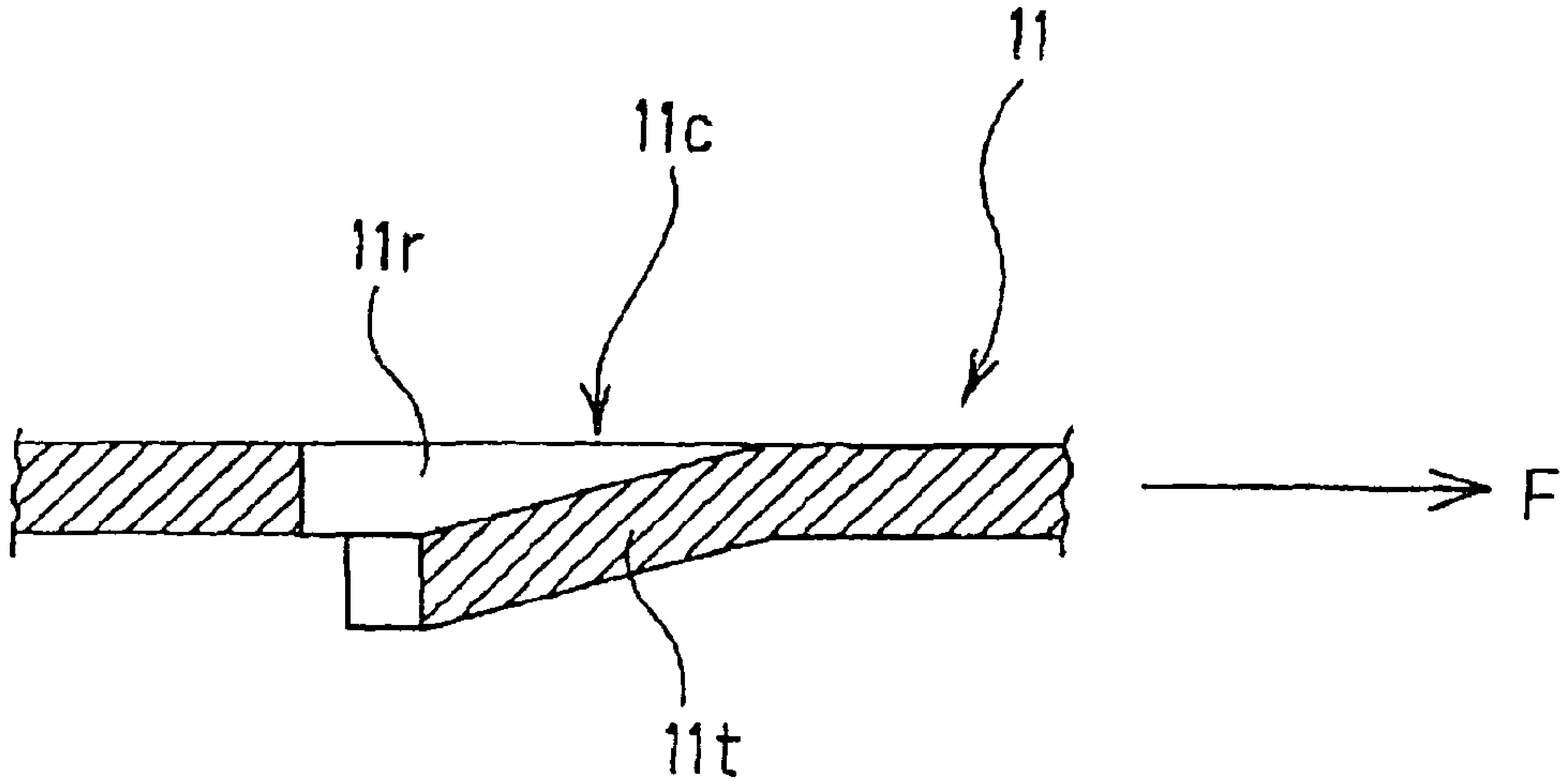

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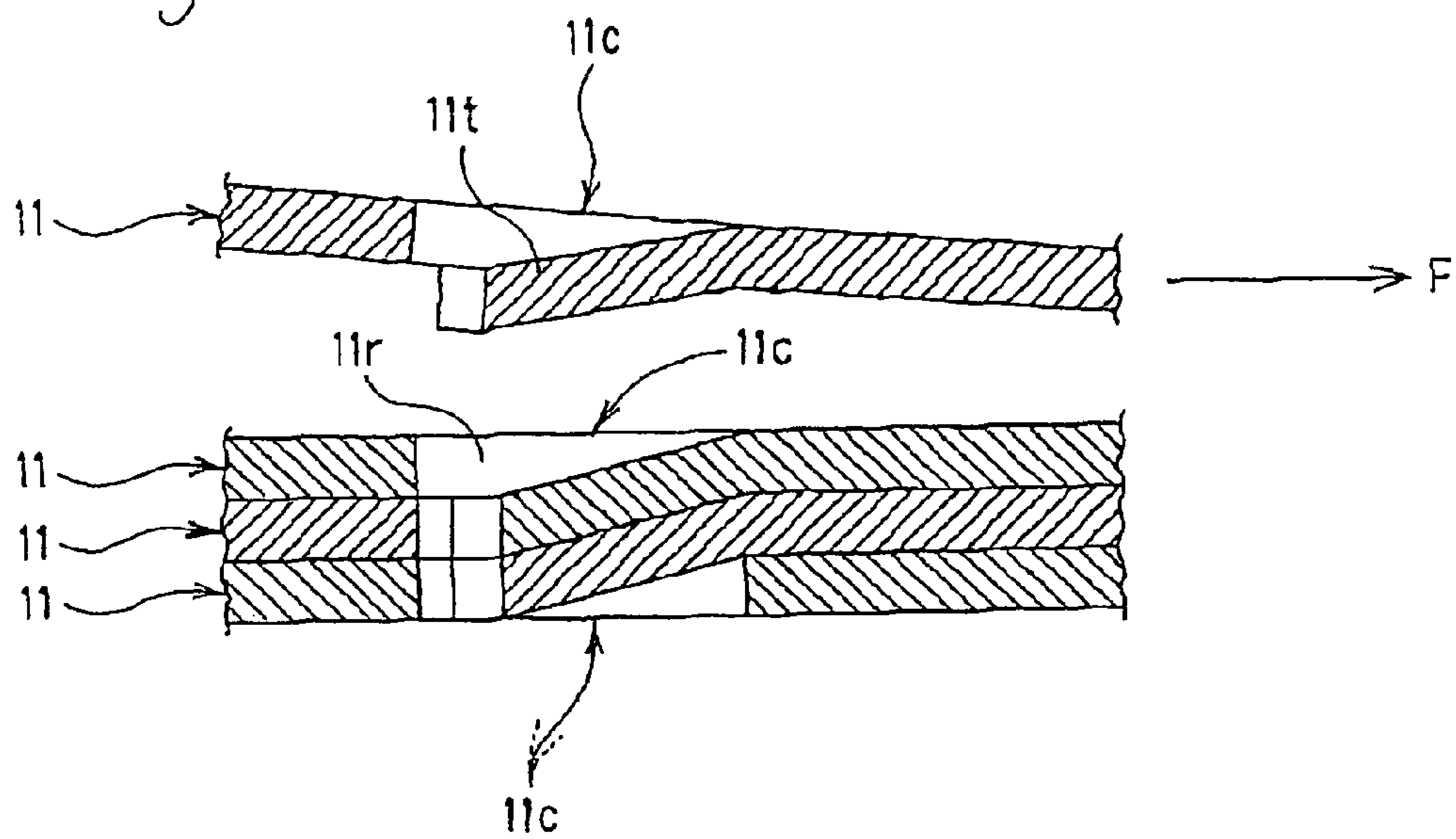

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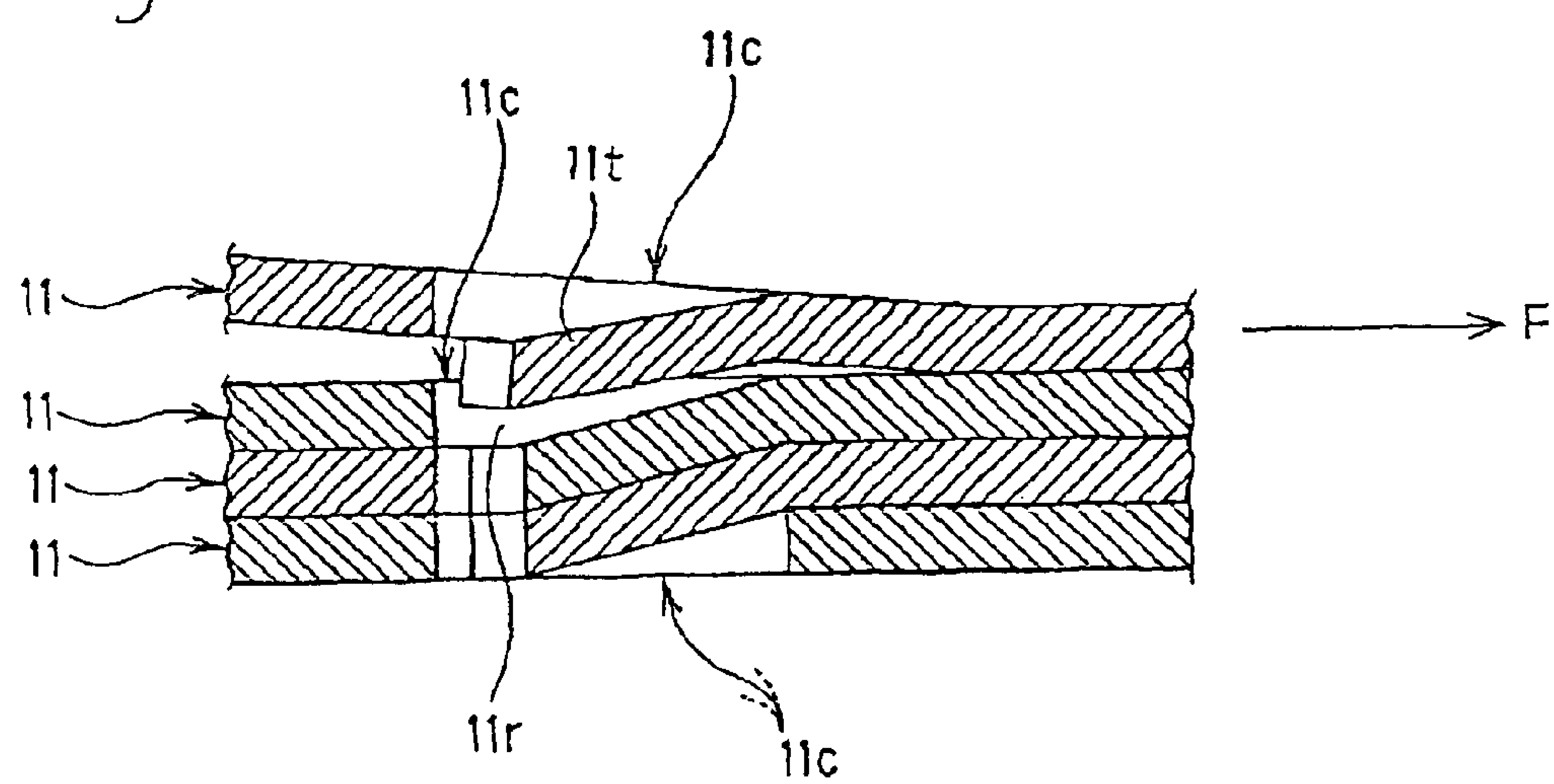

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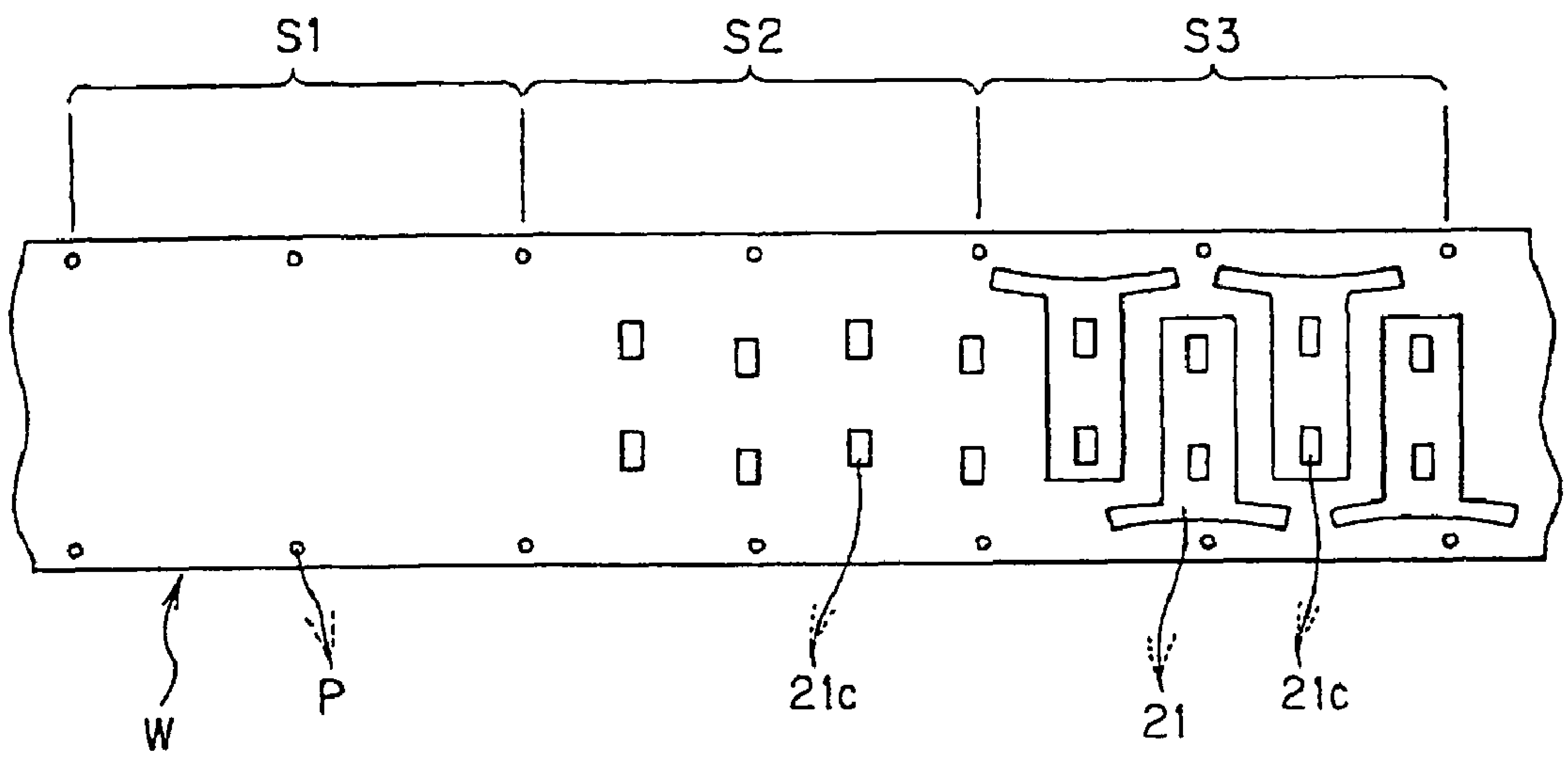

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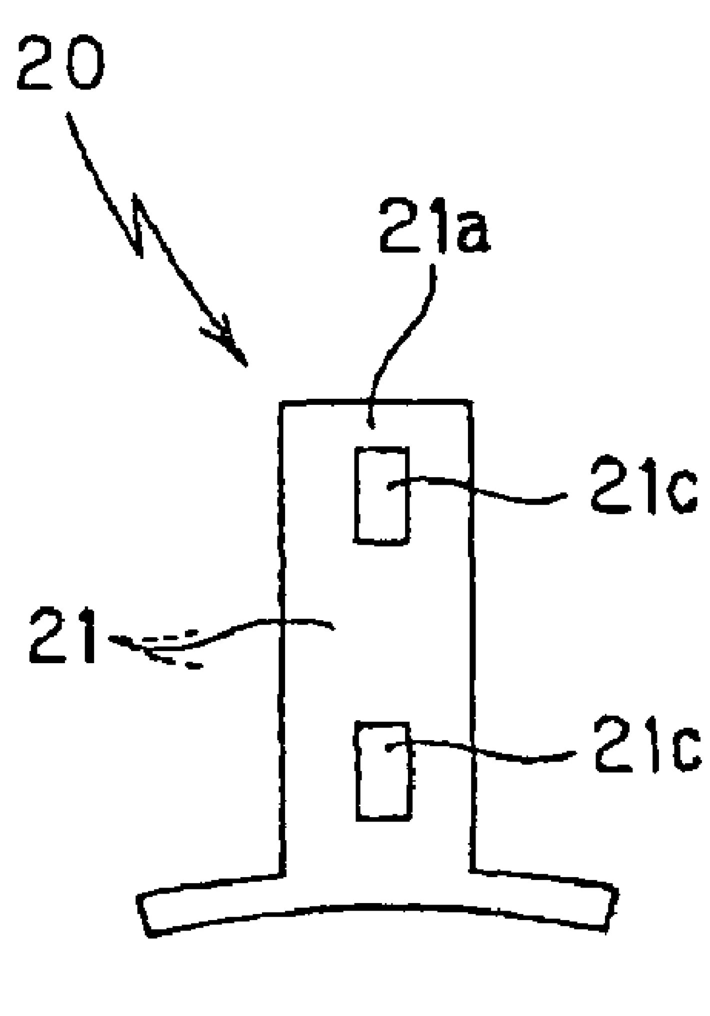

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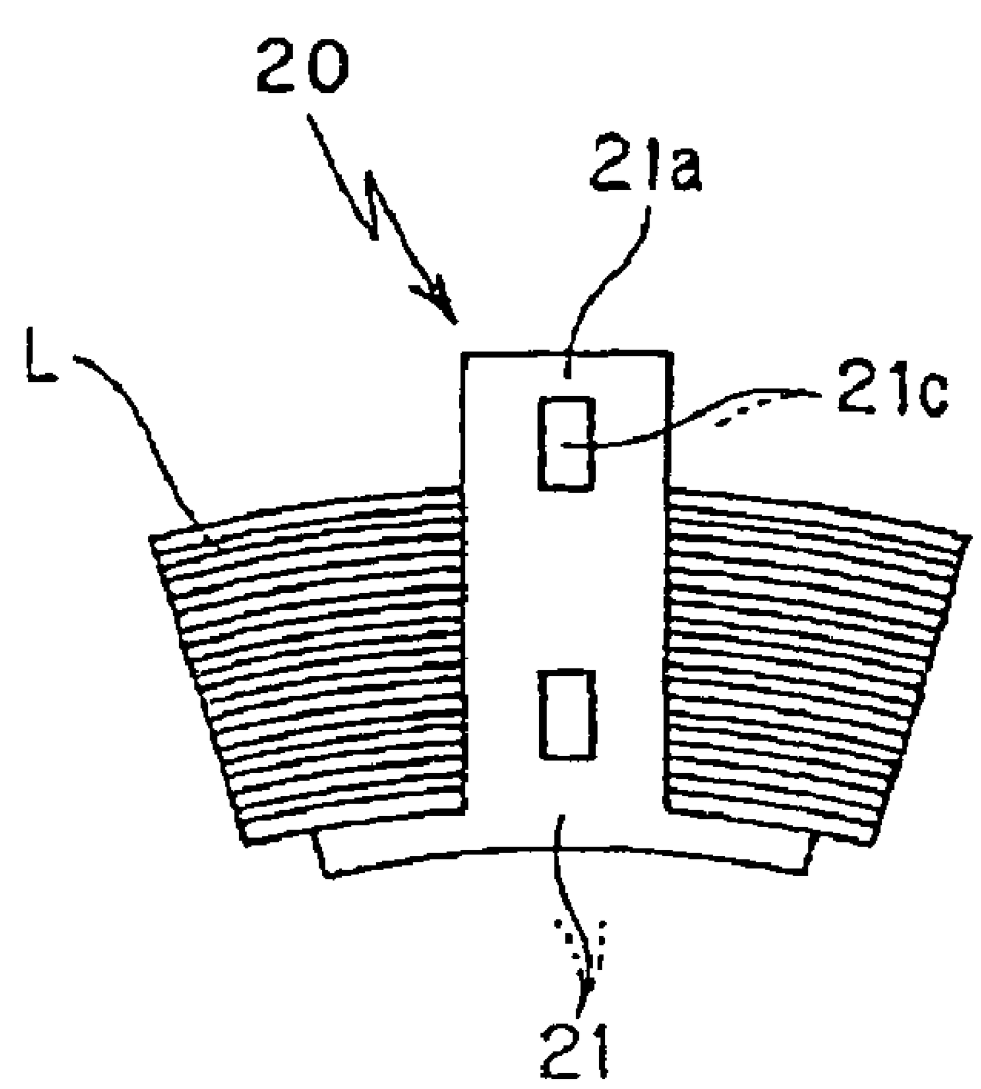

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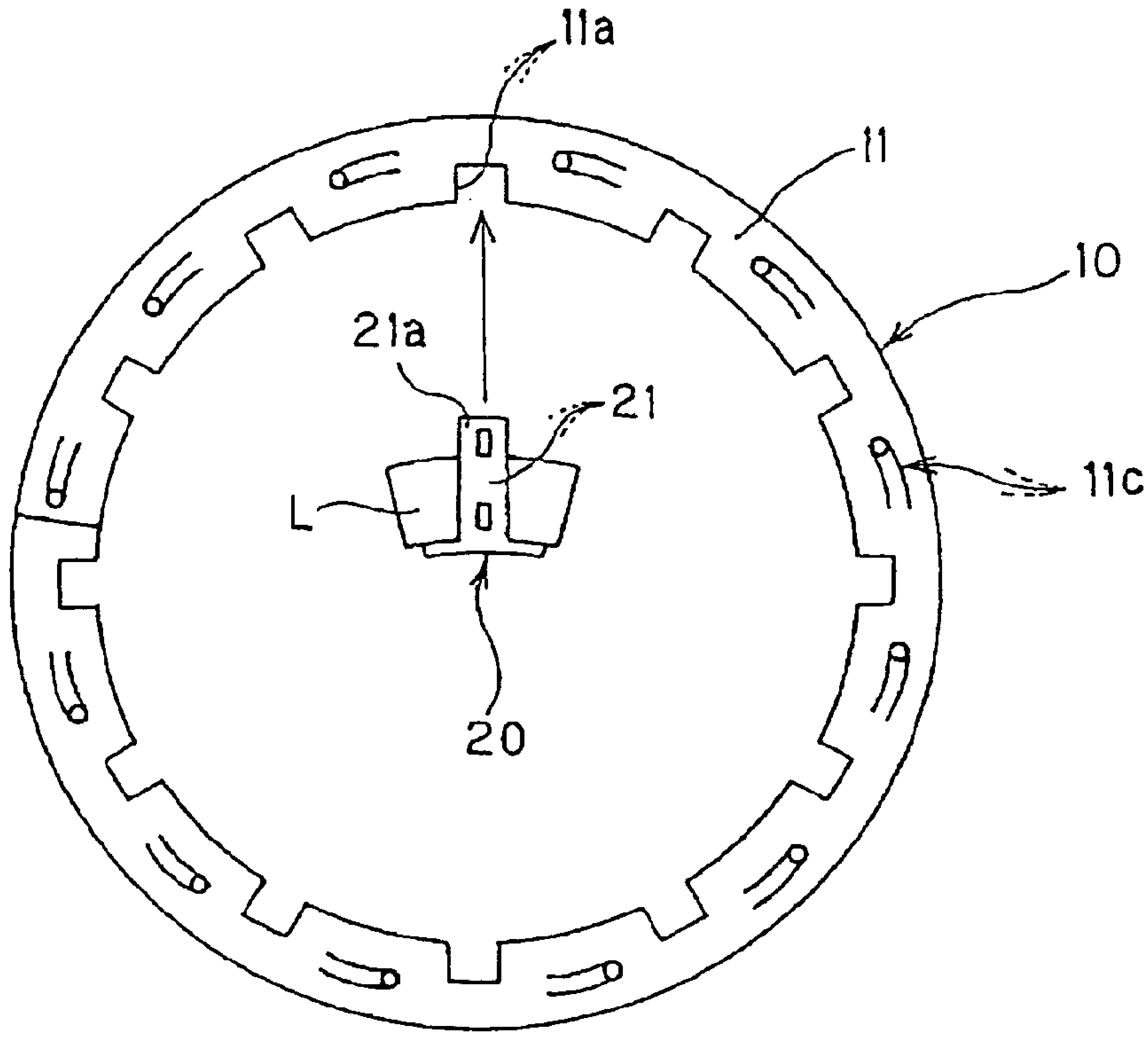

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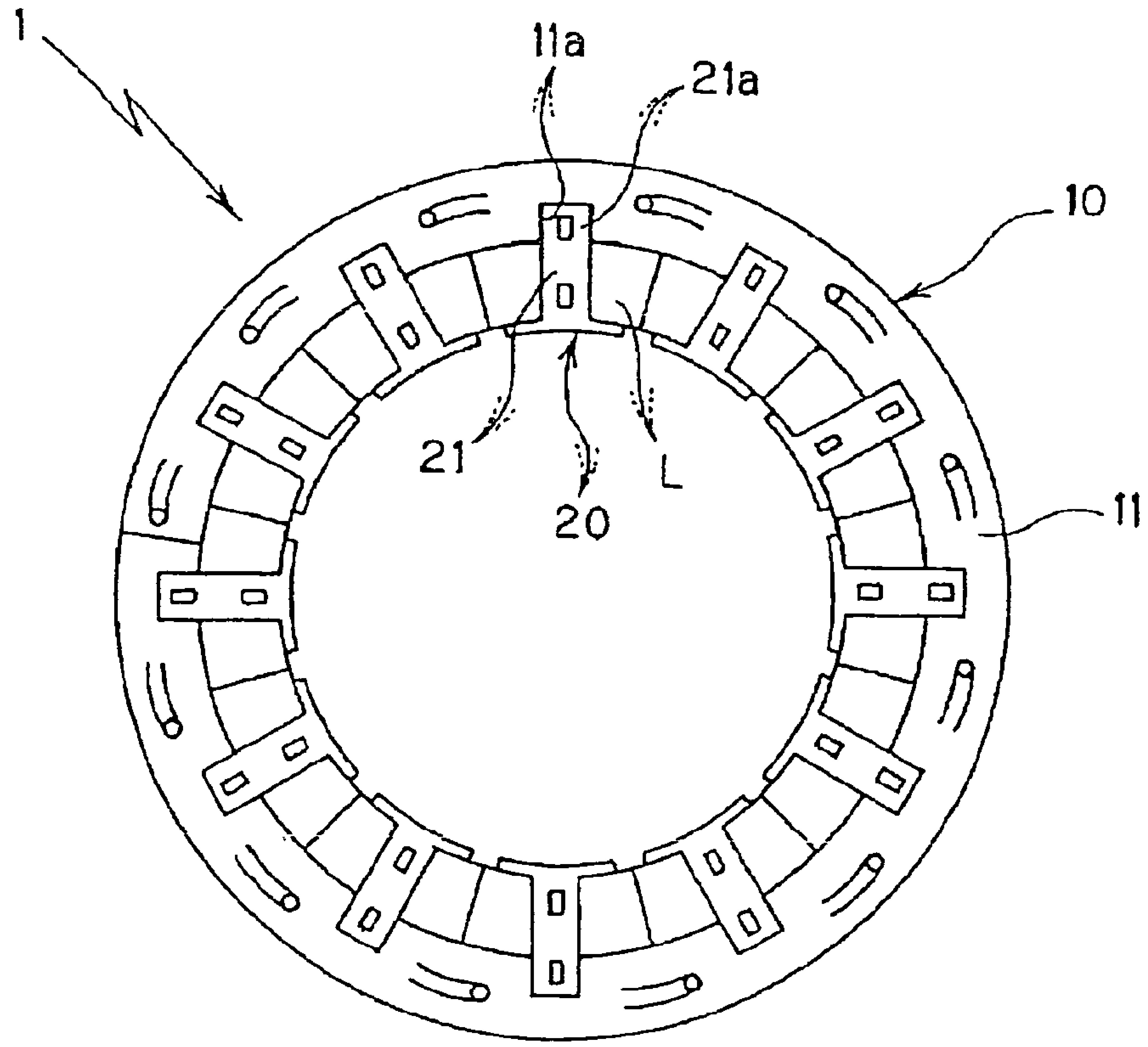

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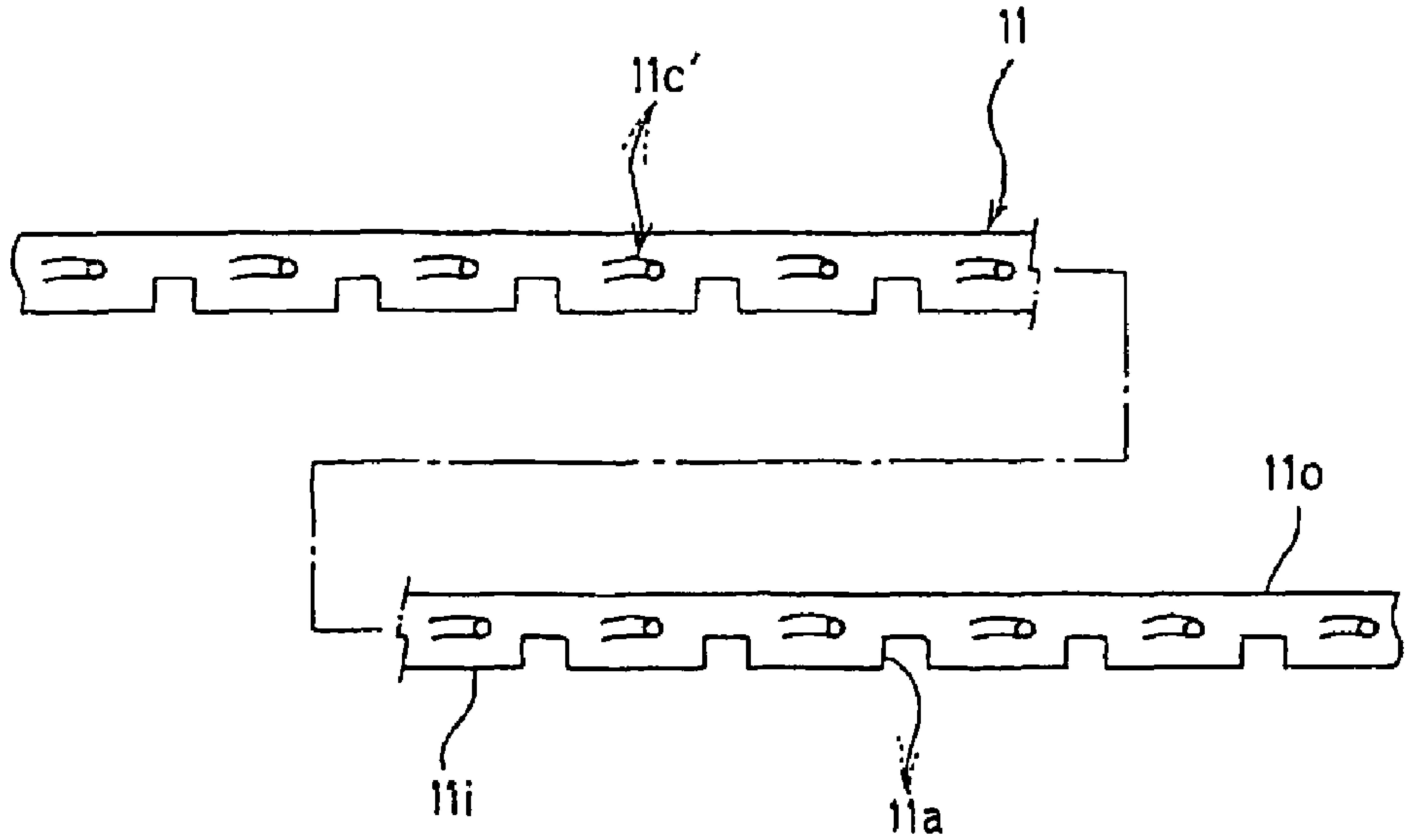

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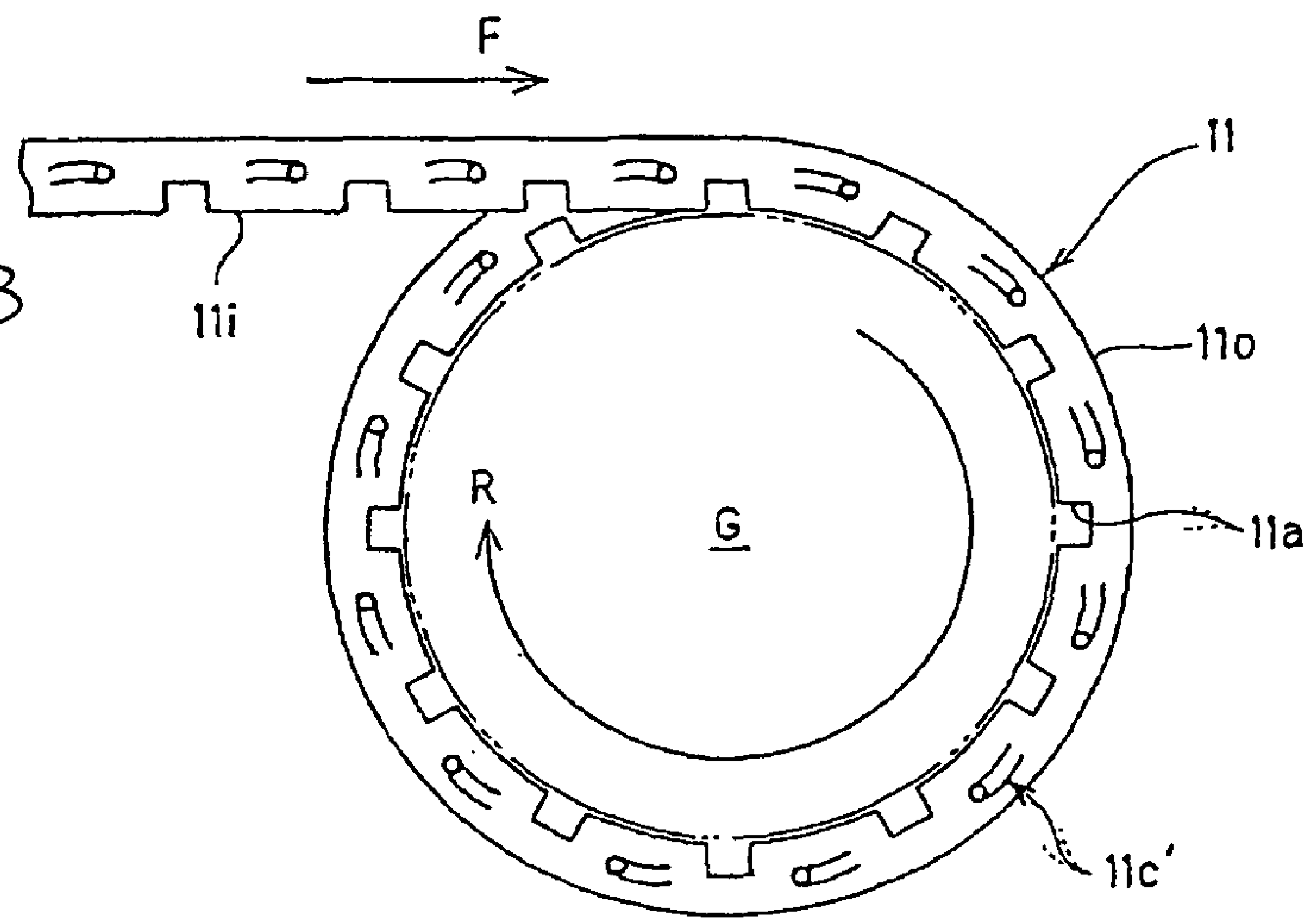

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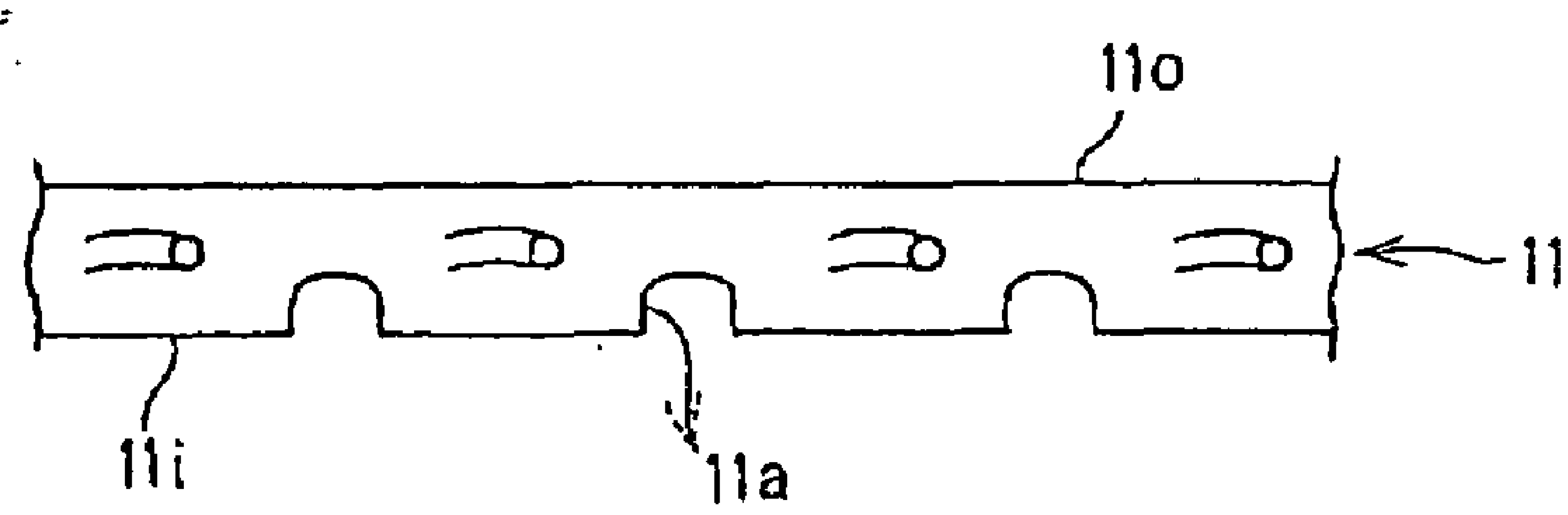

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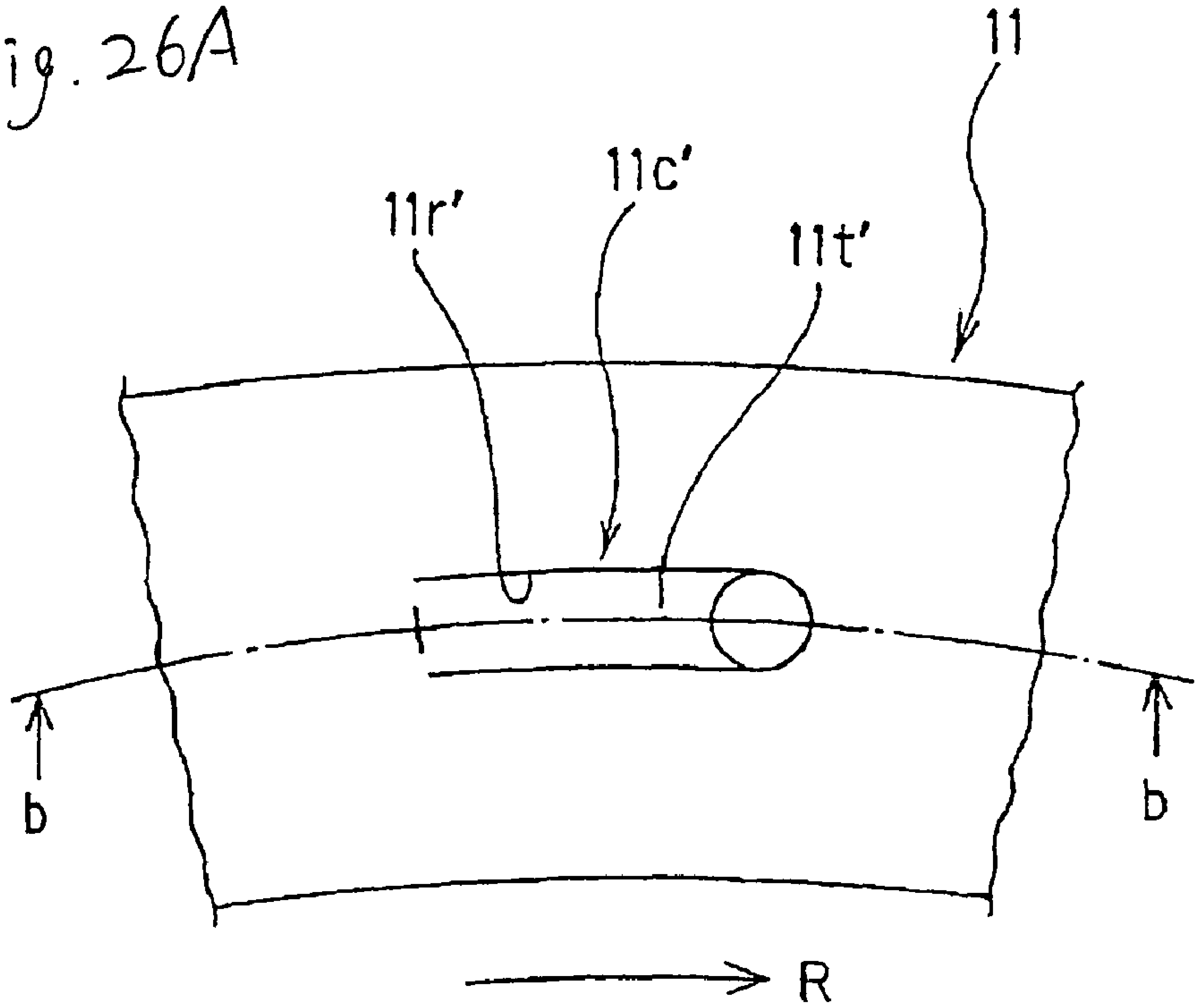

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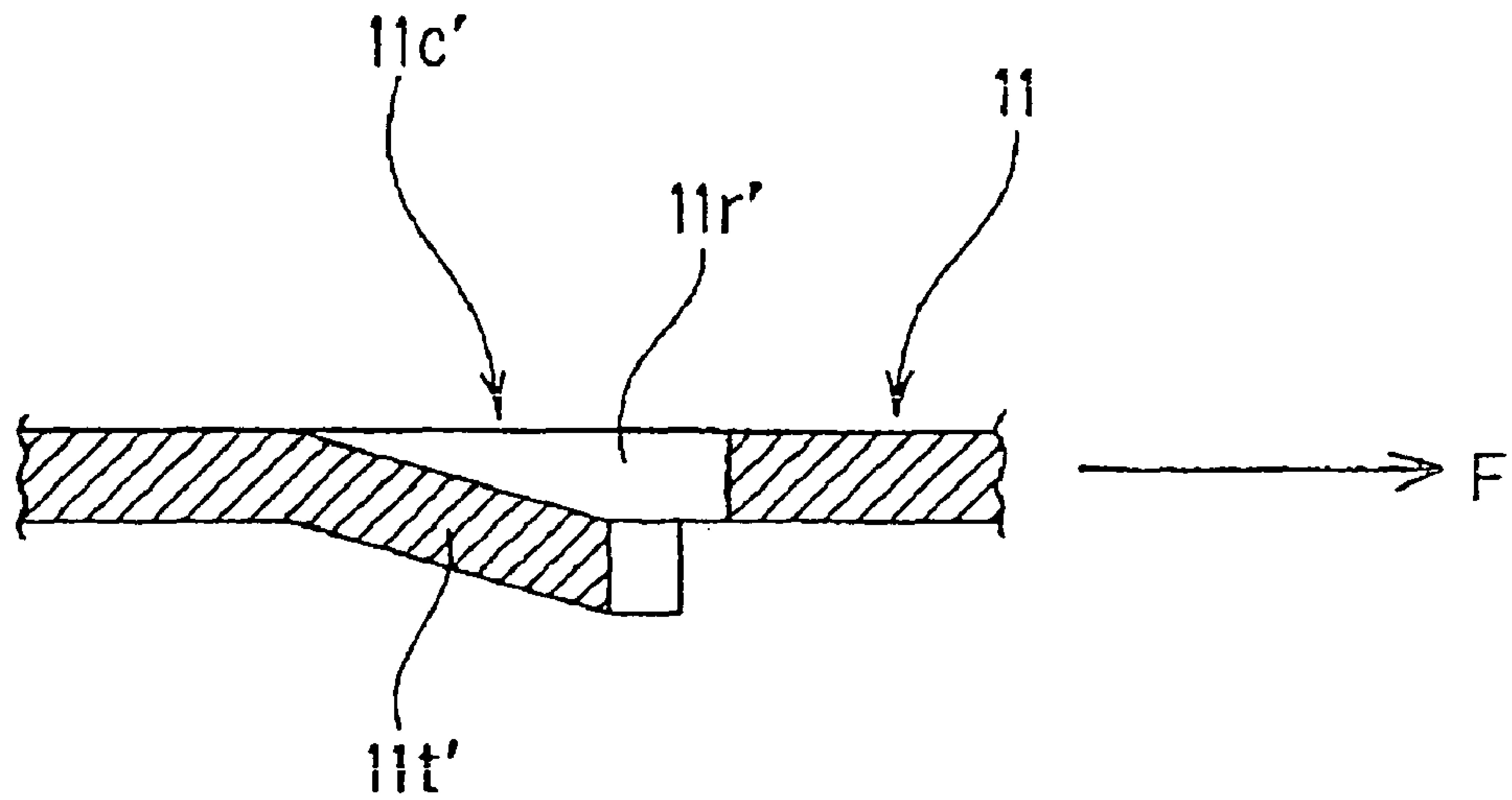

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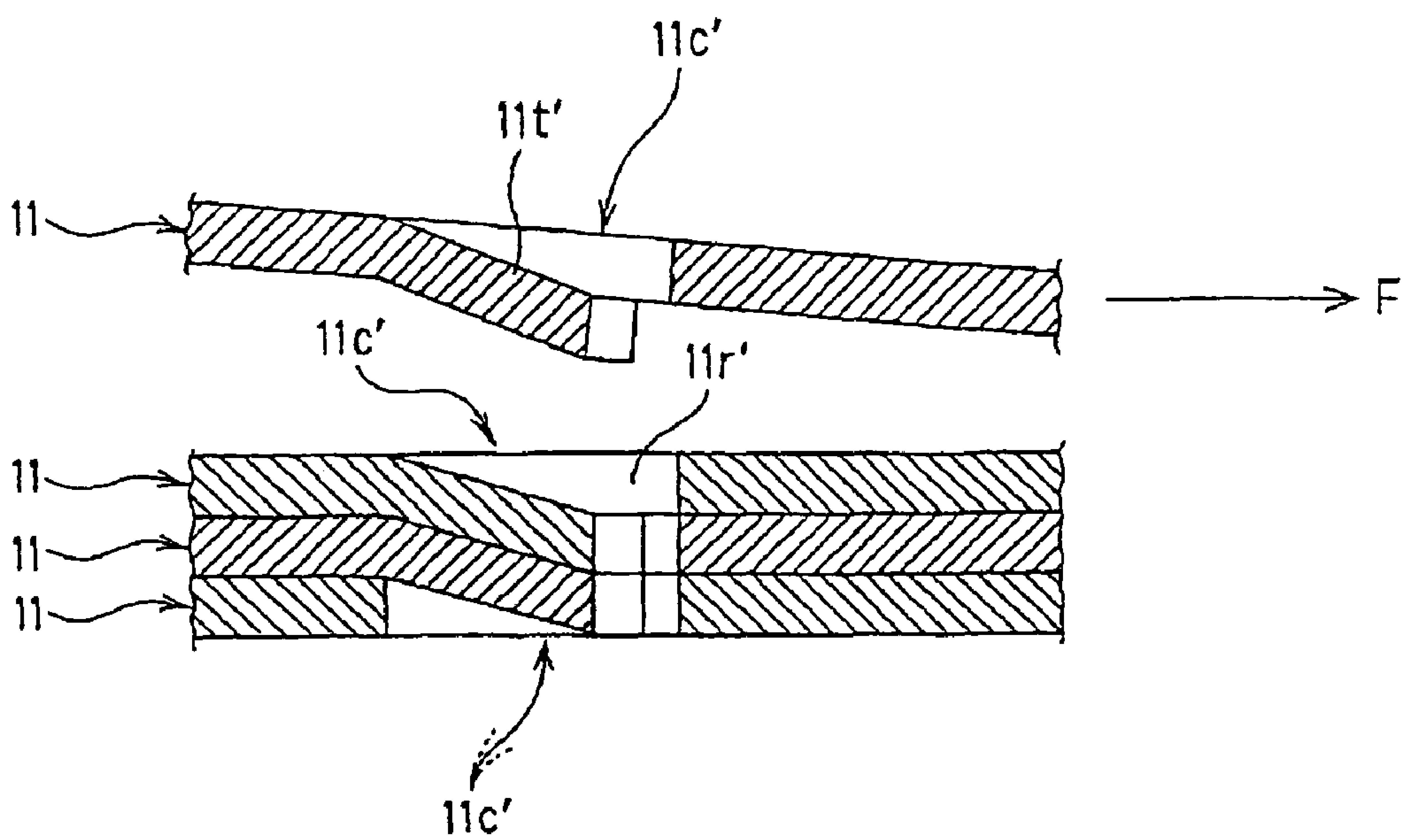

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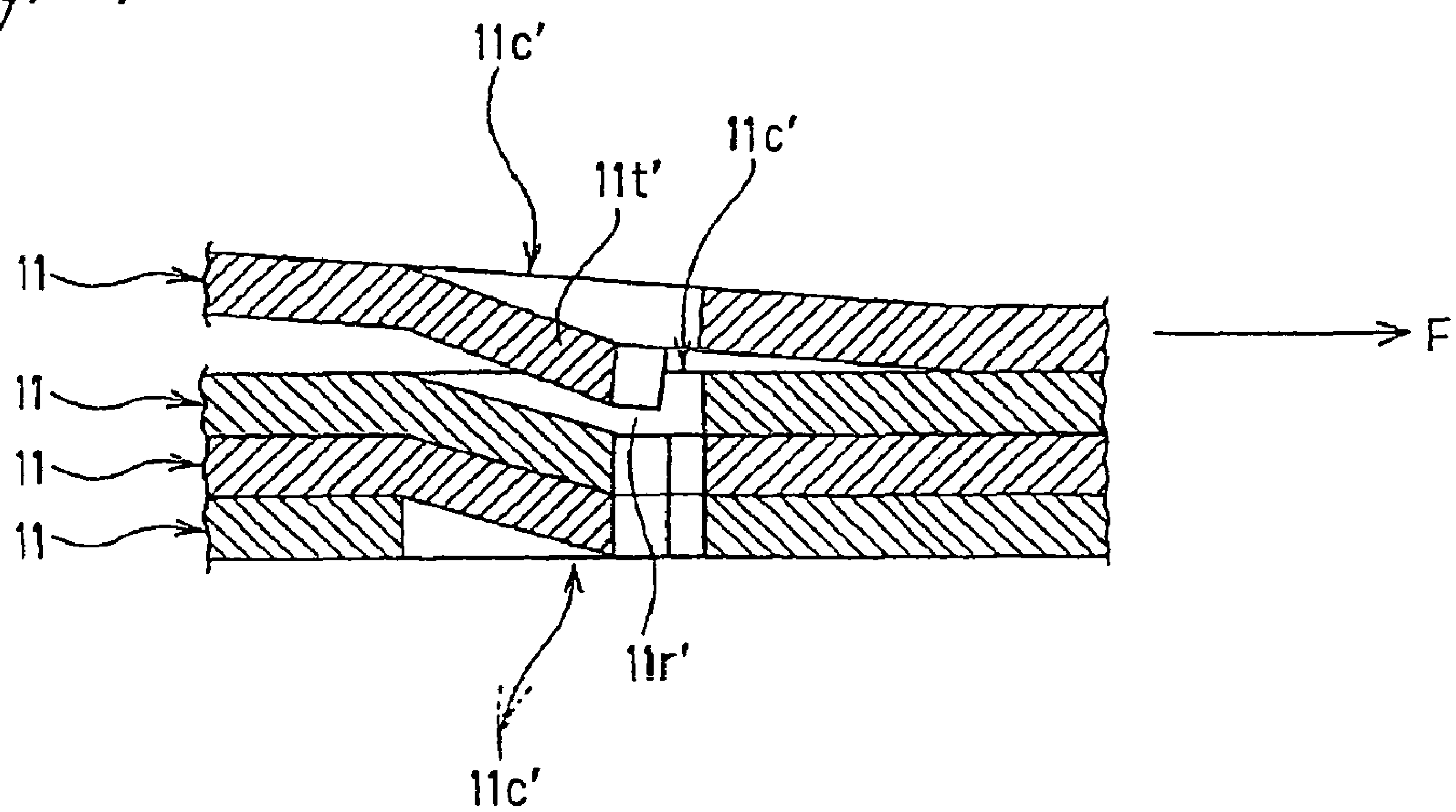

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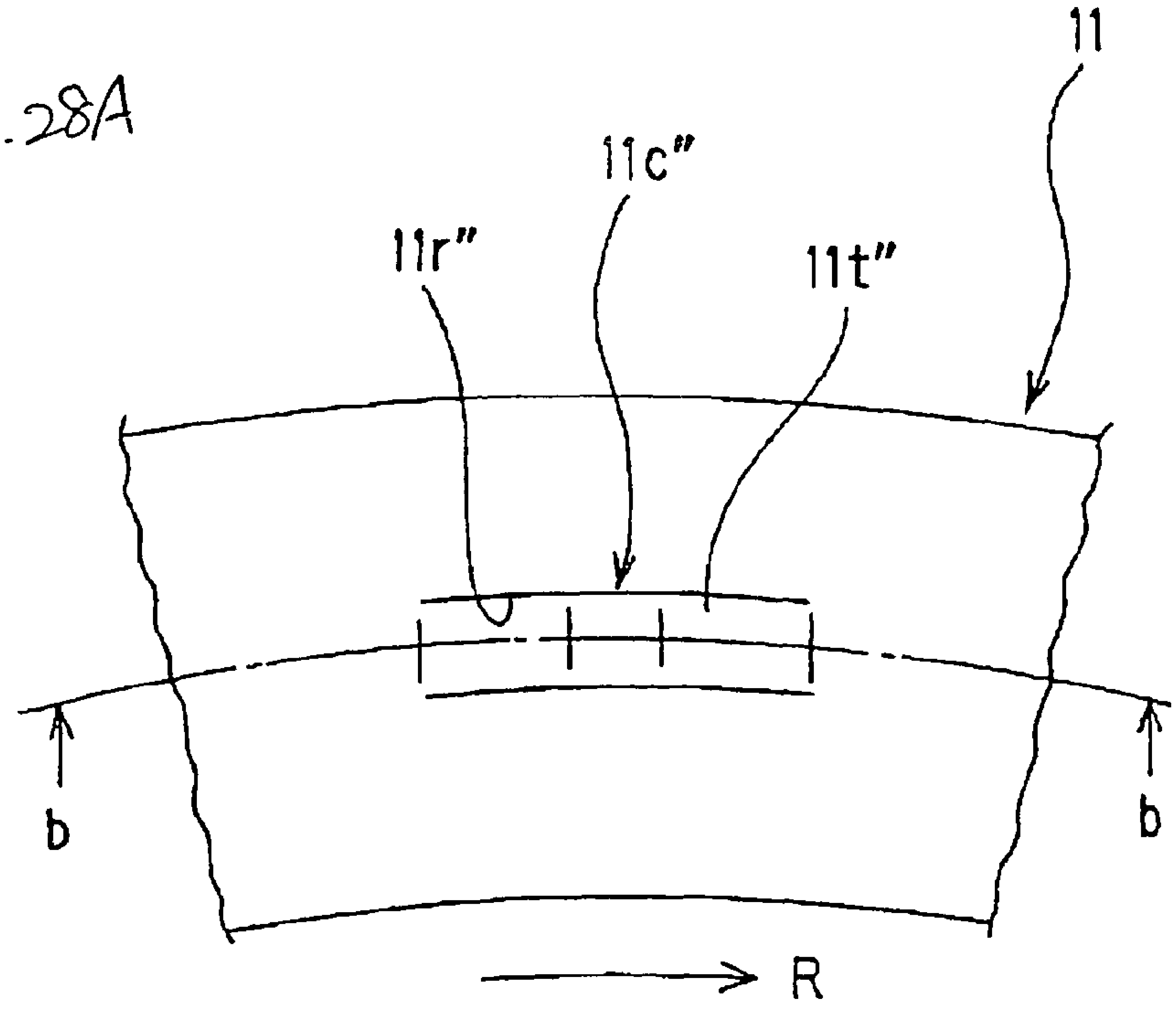

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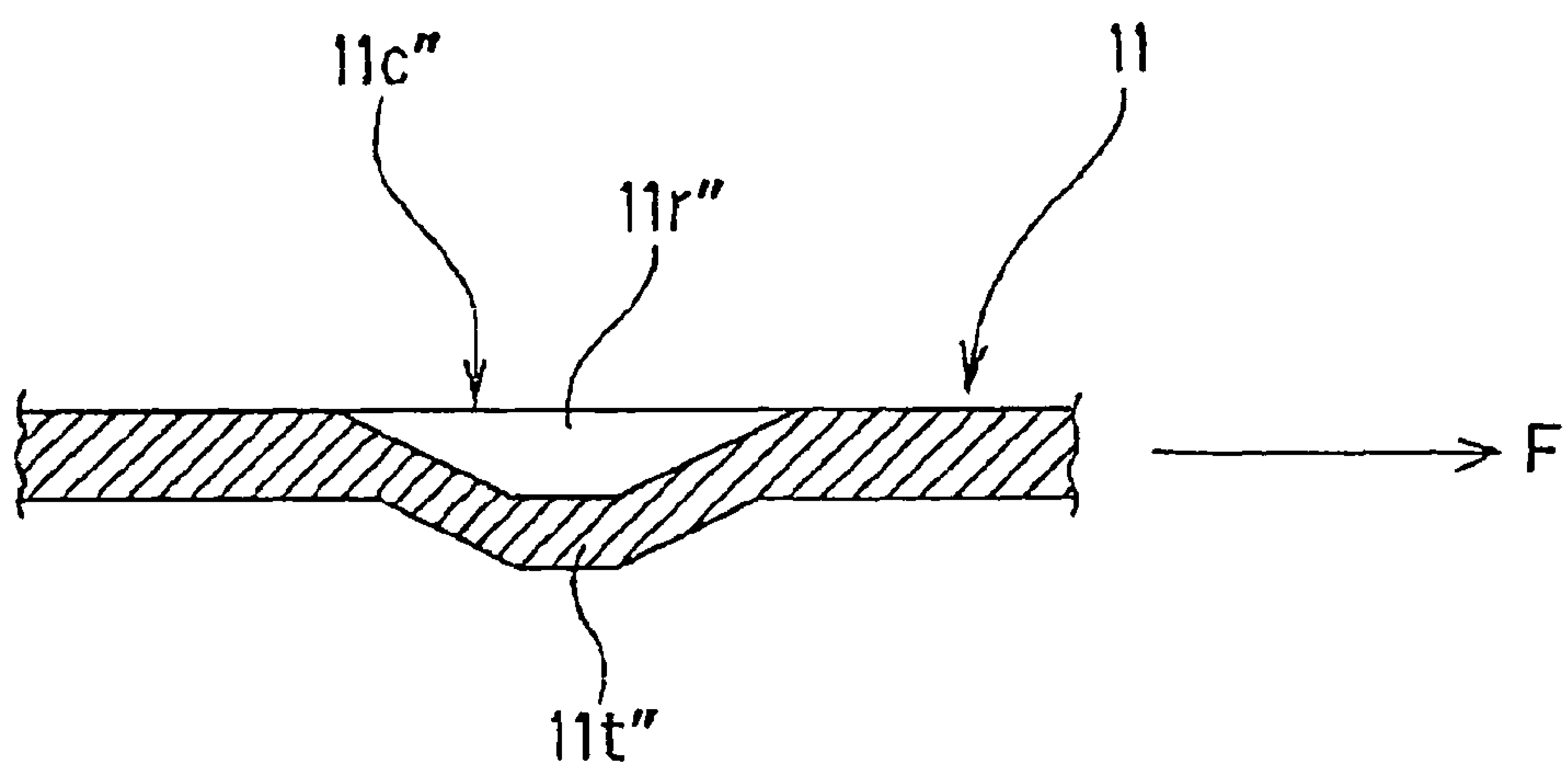

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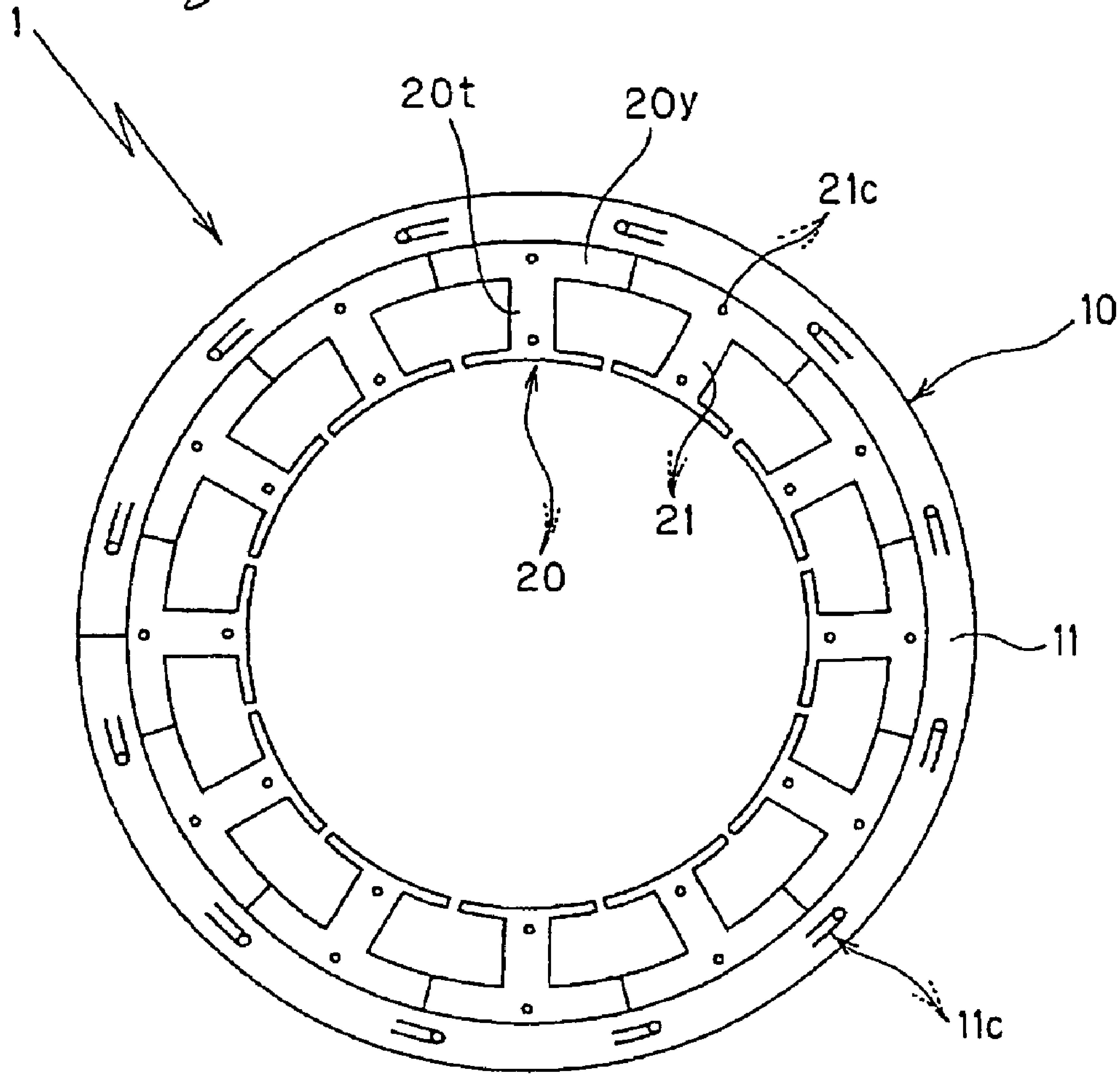


Fig. 29B

Fig. 30A

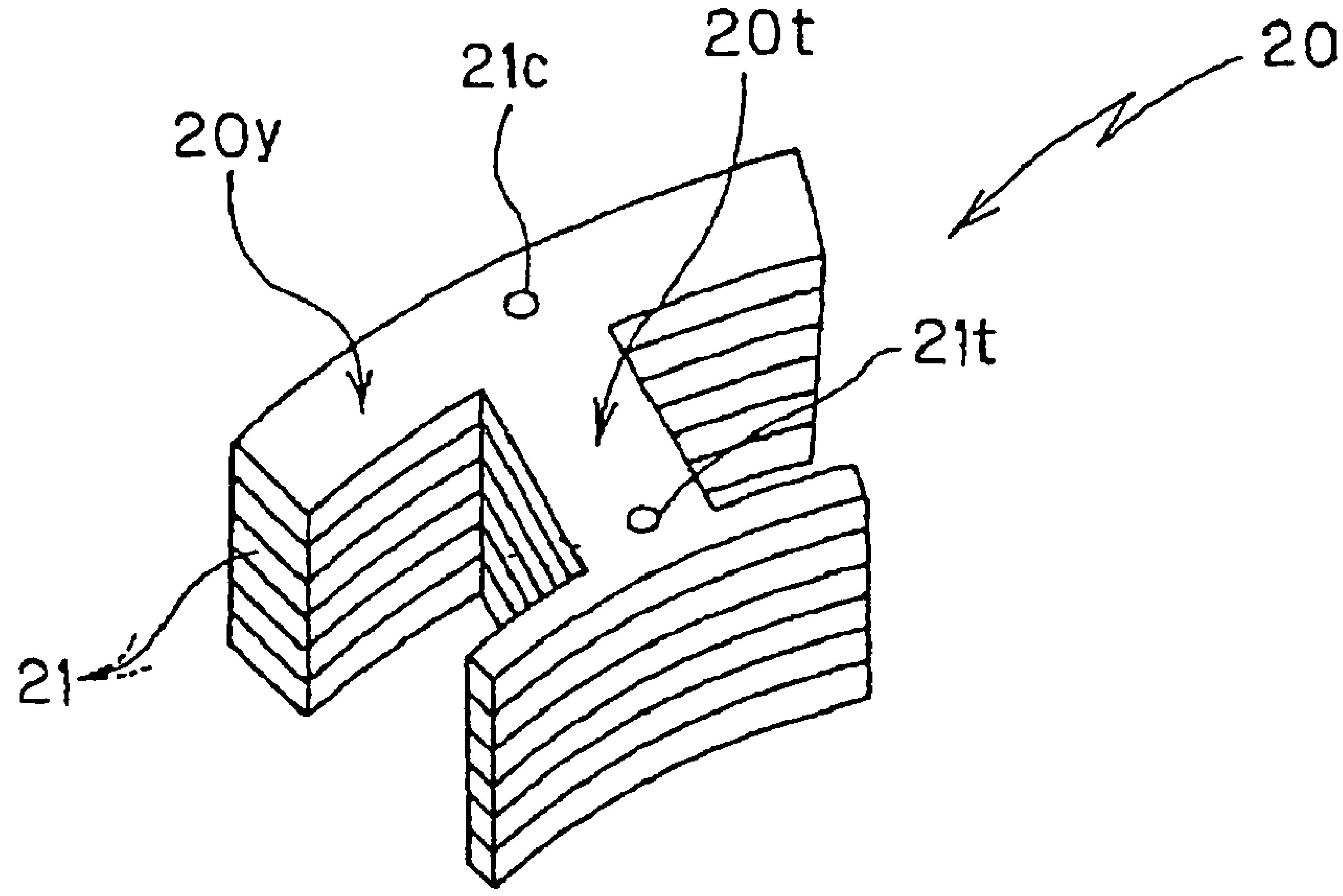


Fig. 30B

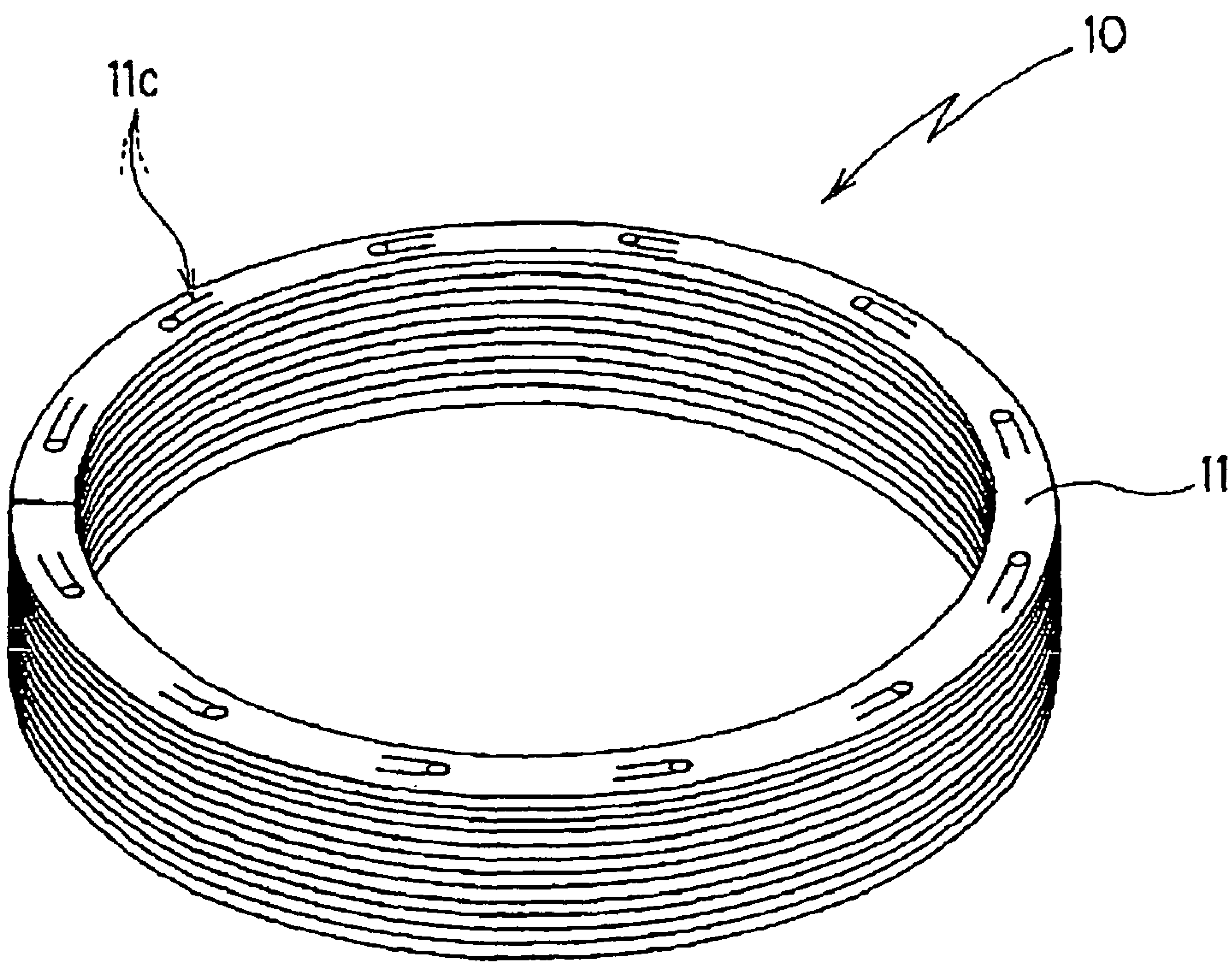


Fig. 31A

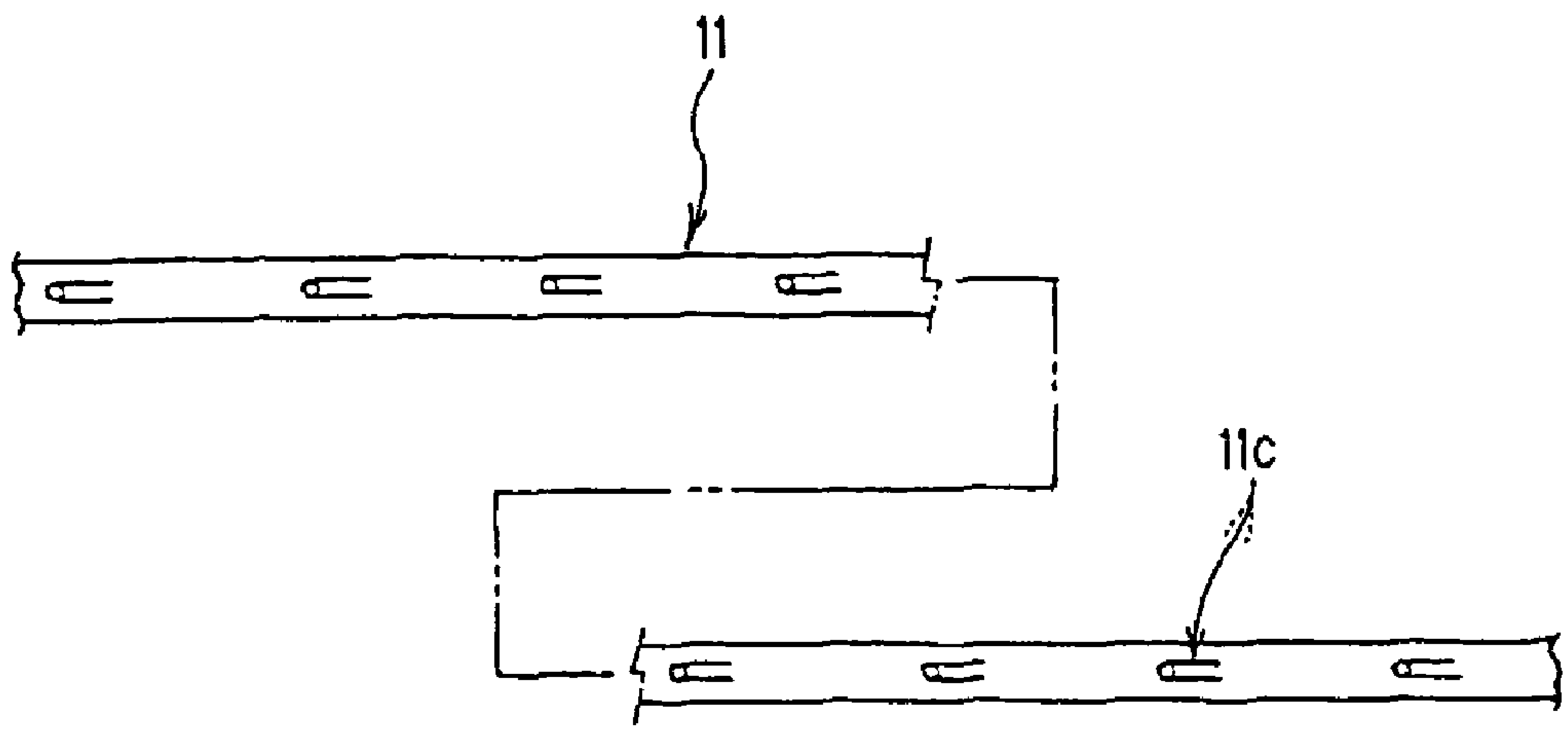


Fig. 31B

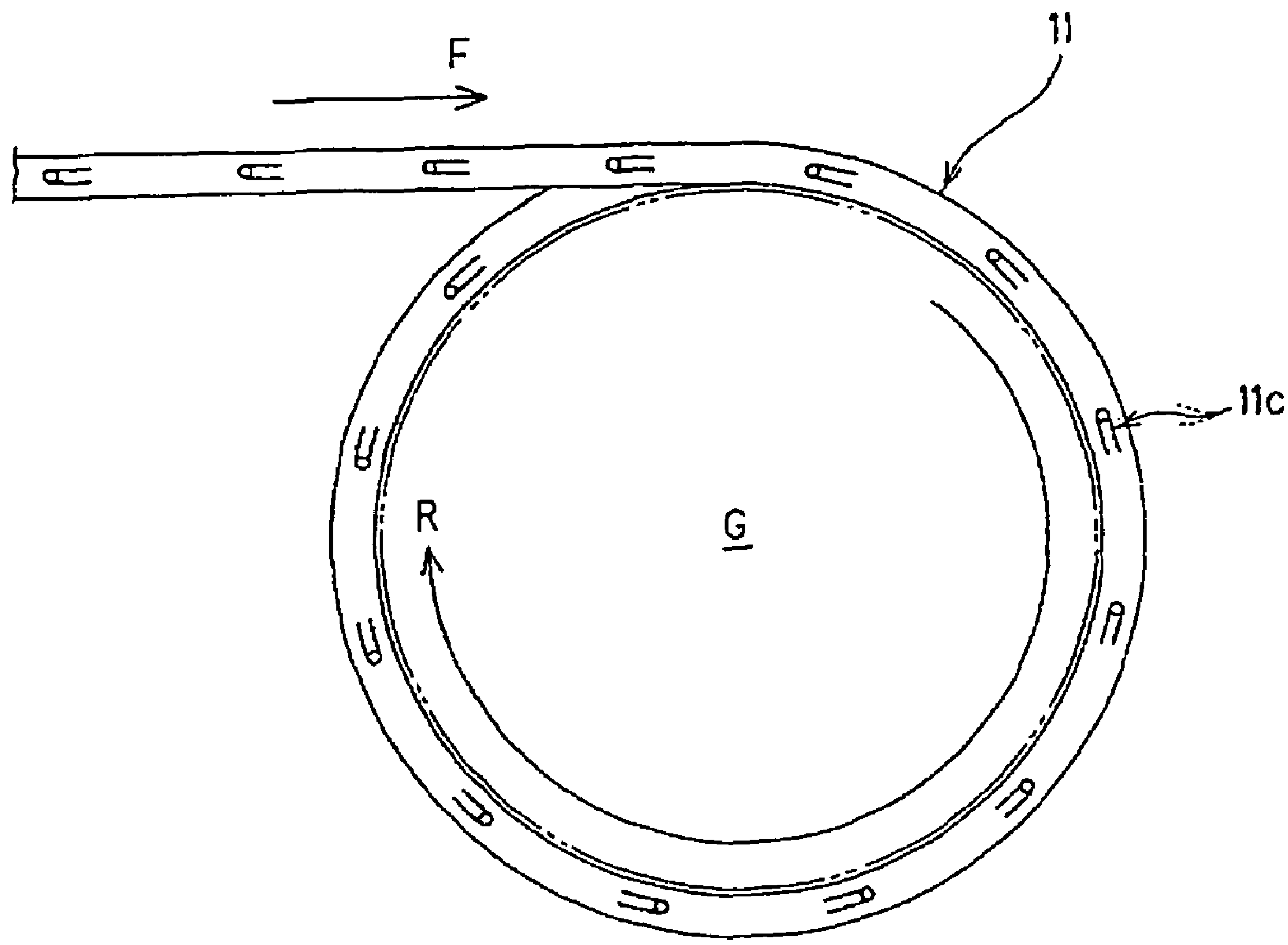


Fig. 32A

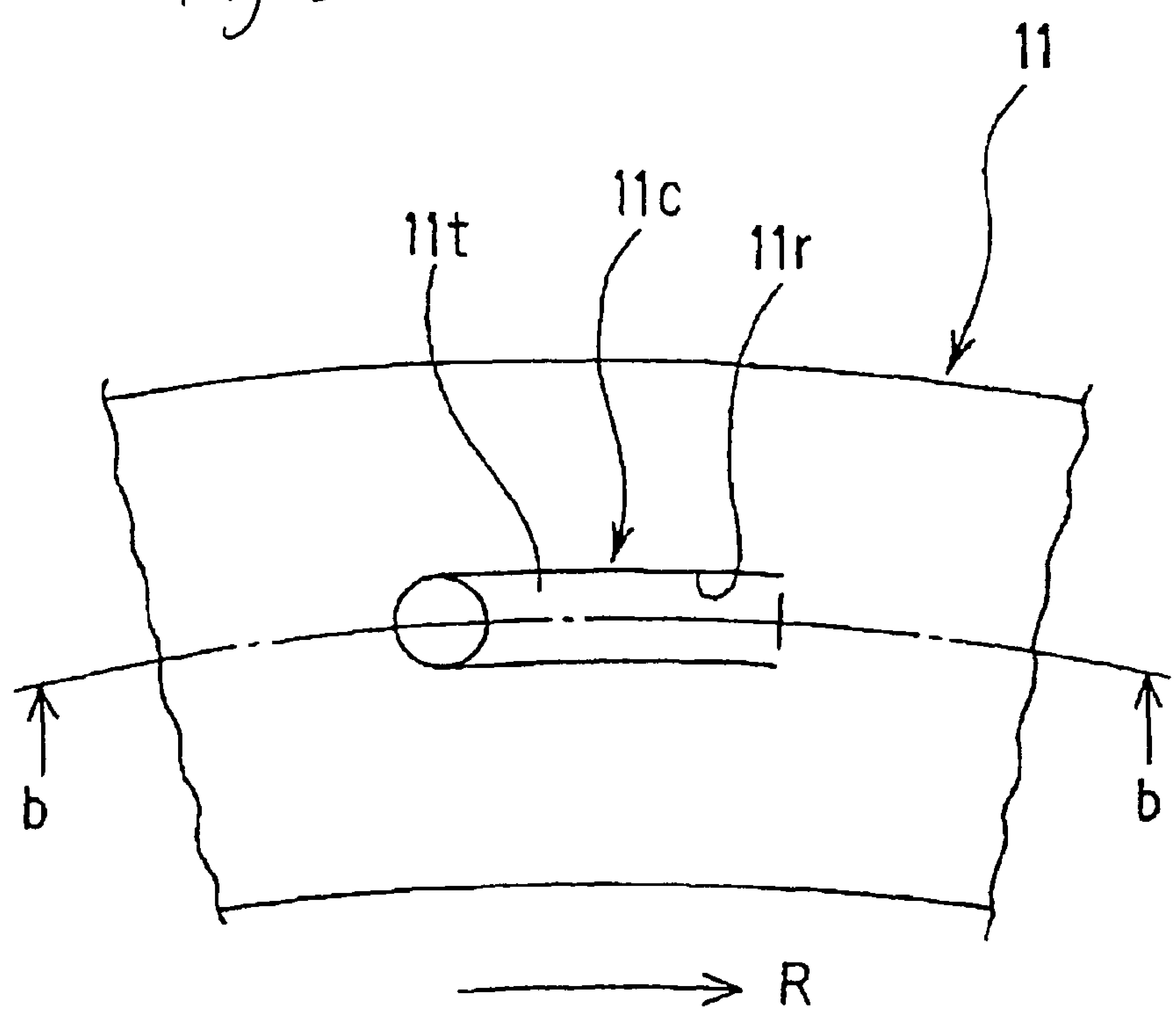


Fig. 32B

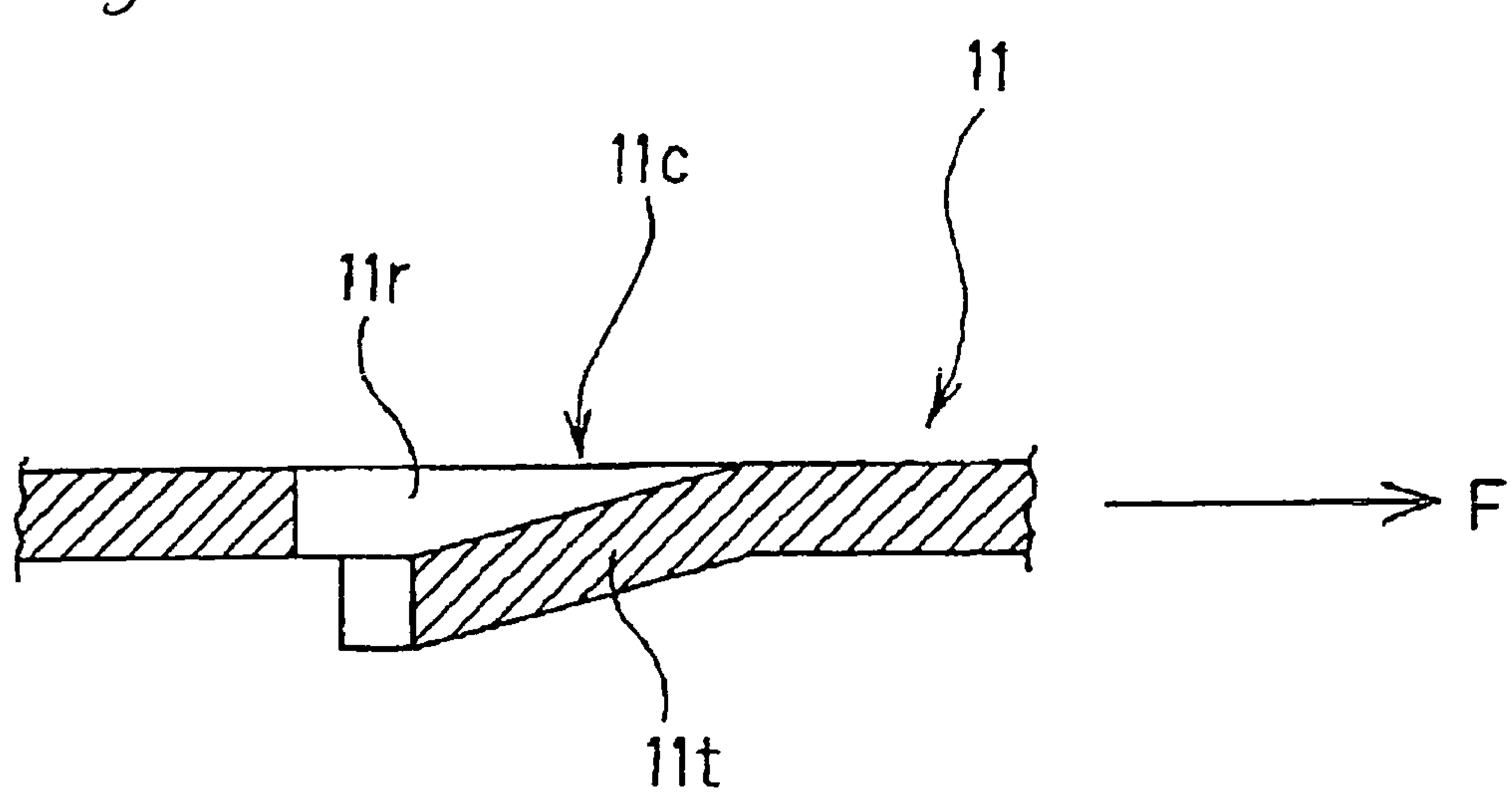


Fig. 33A

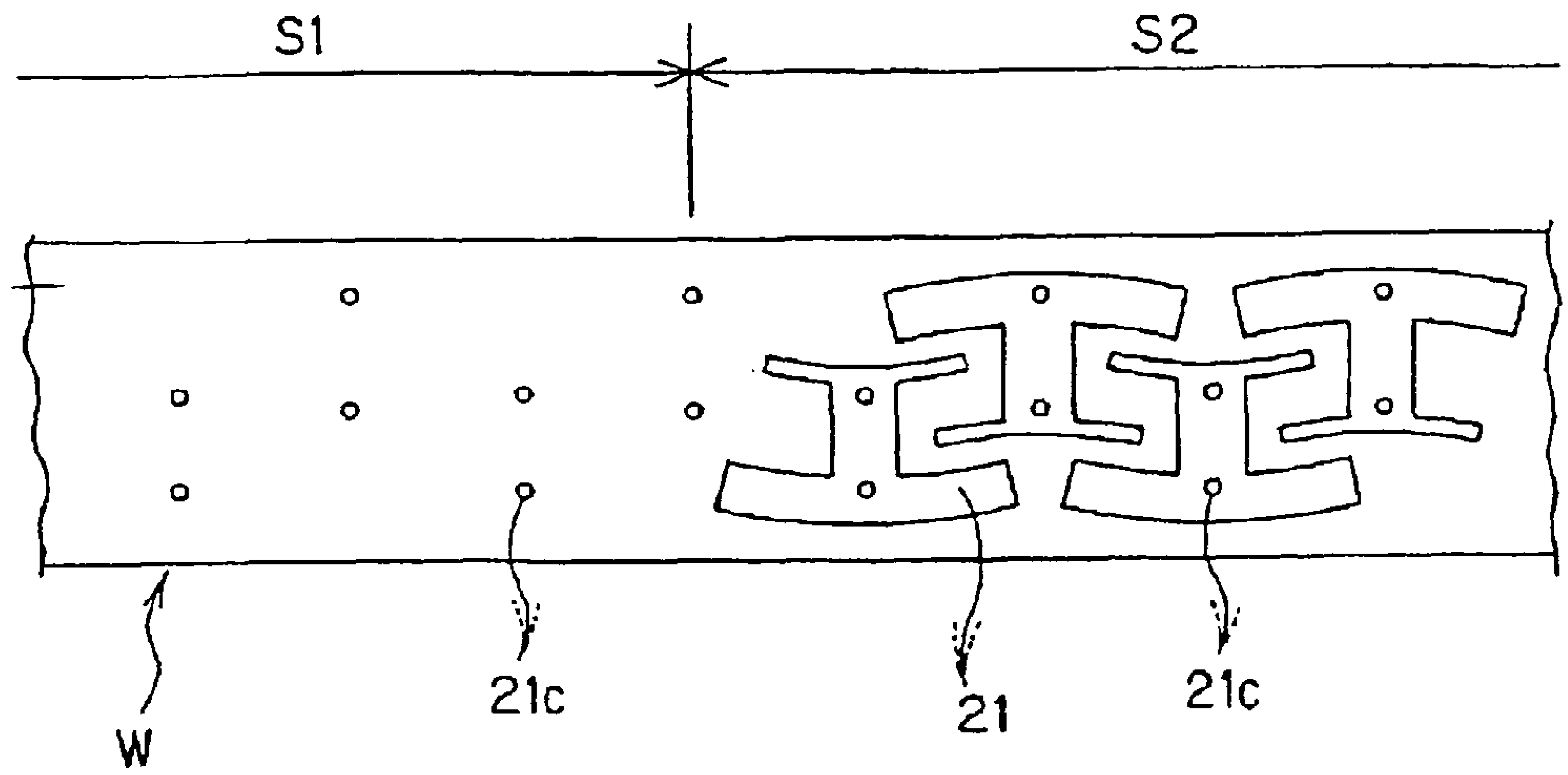


Fig. 33B

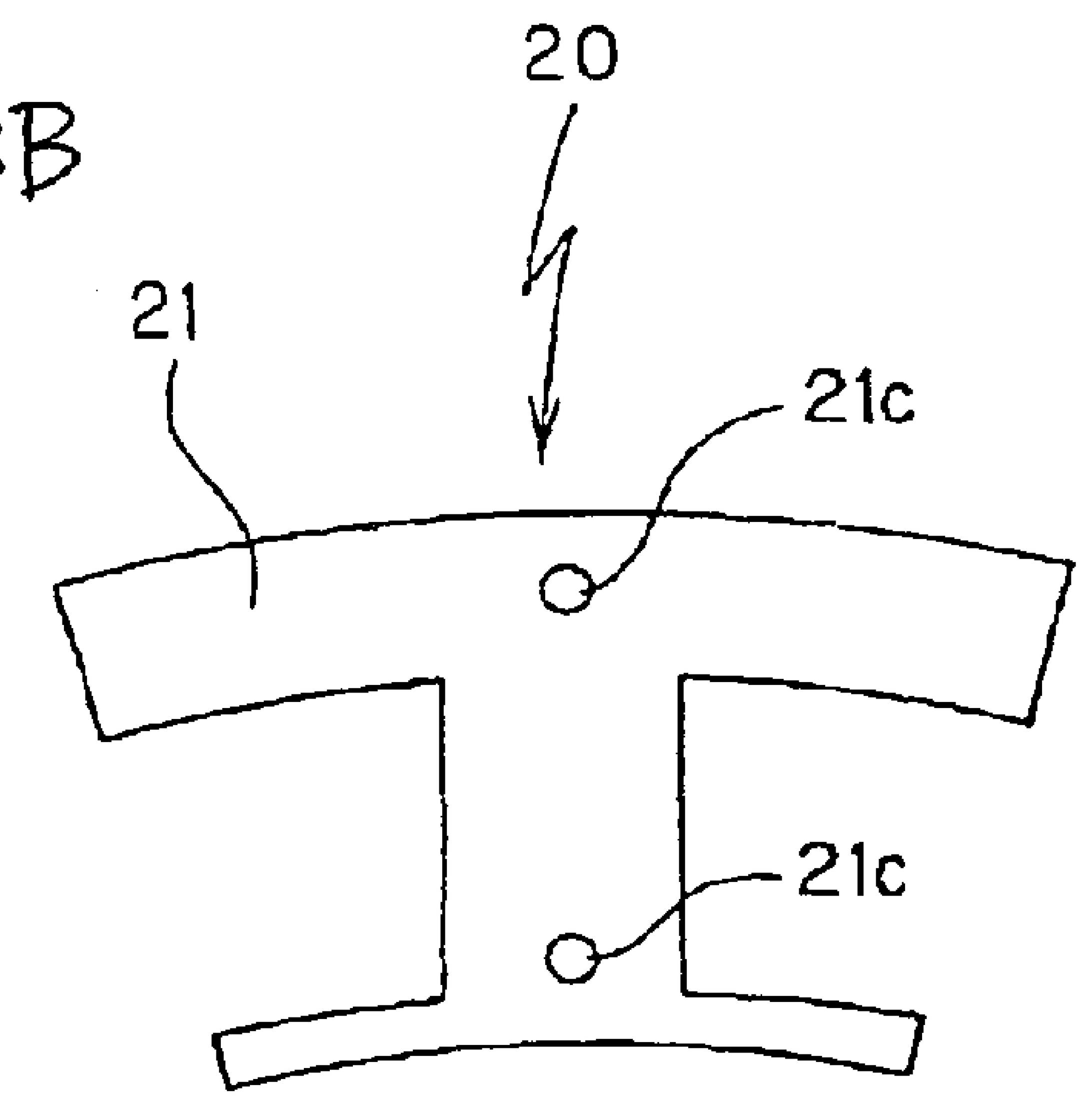


Fig. 33C

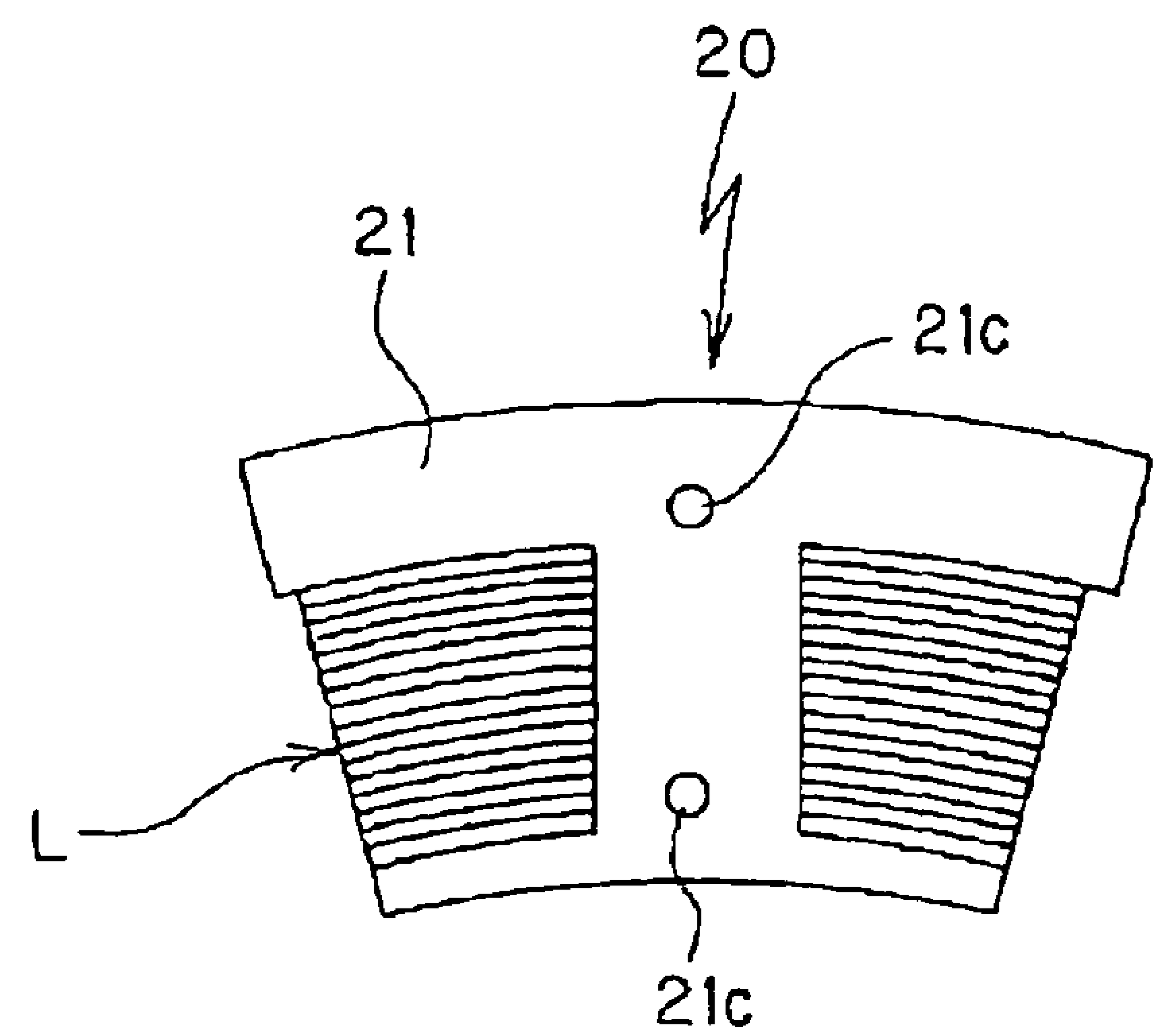


Fig. 34

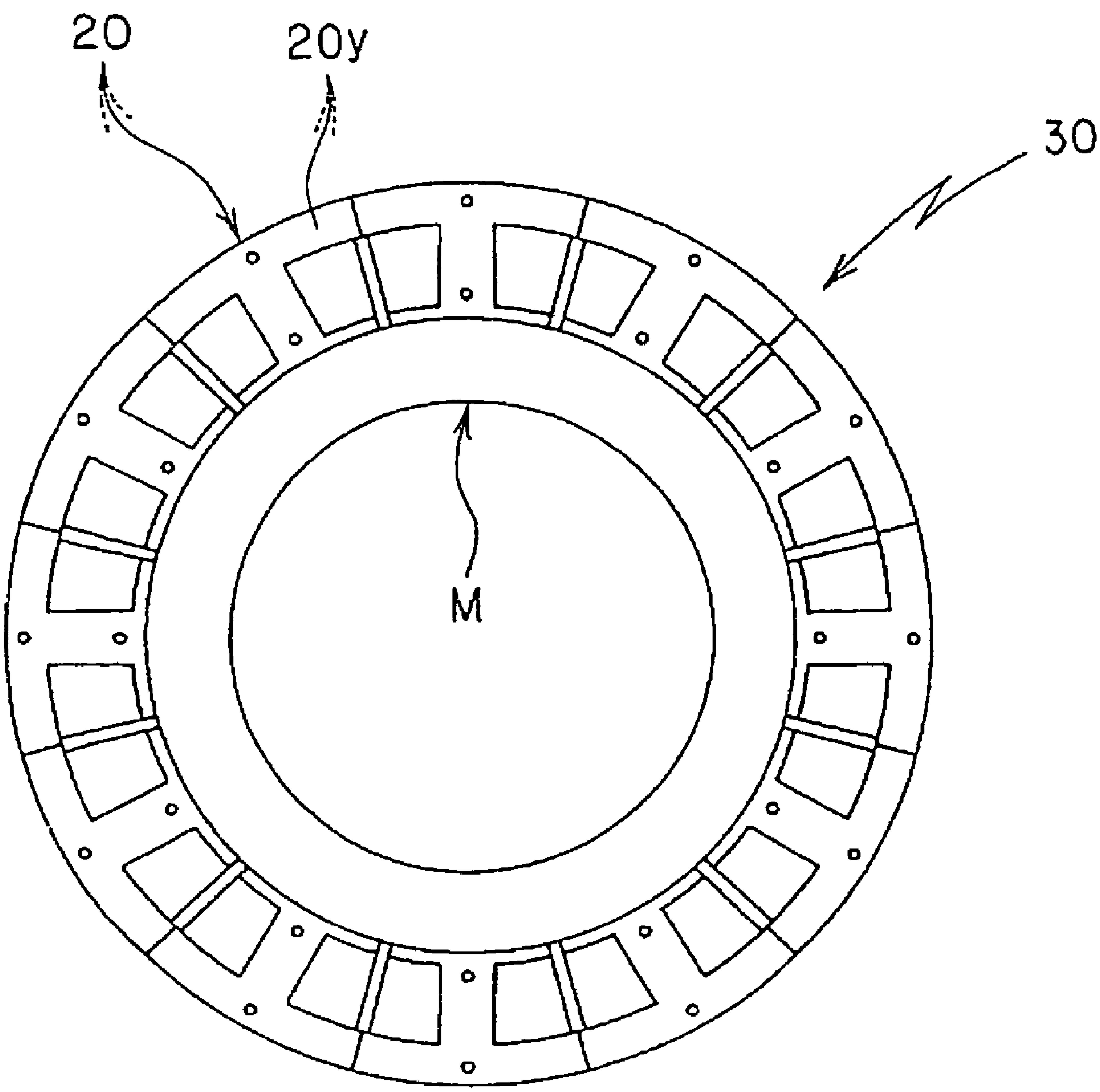


Fig. 35

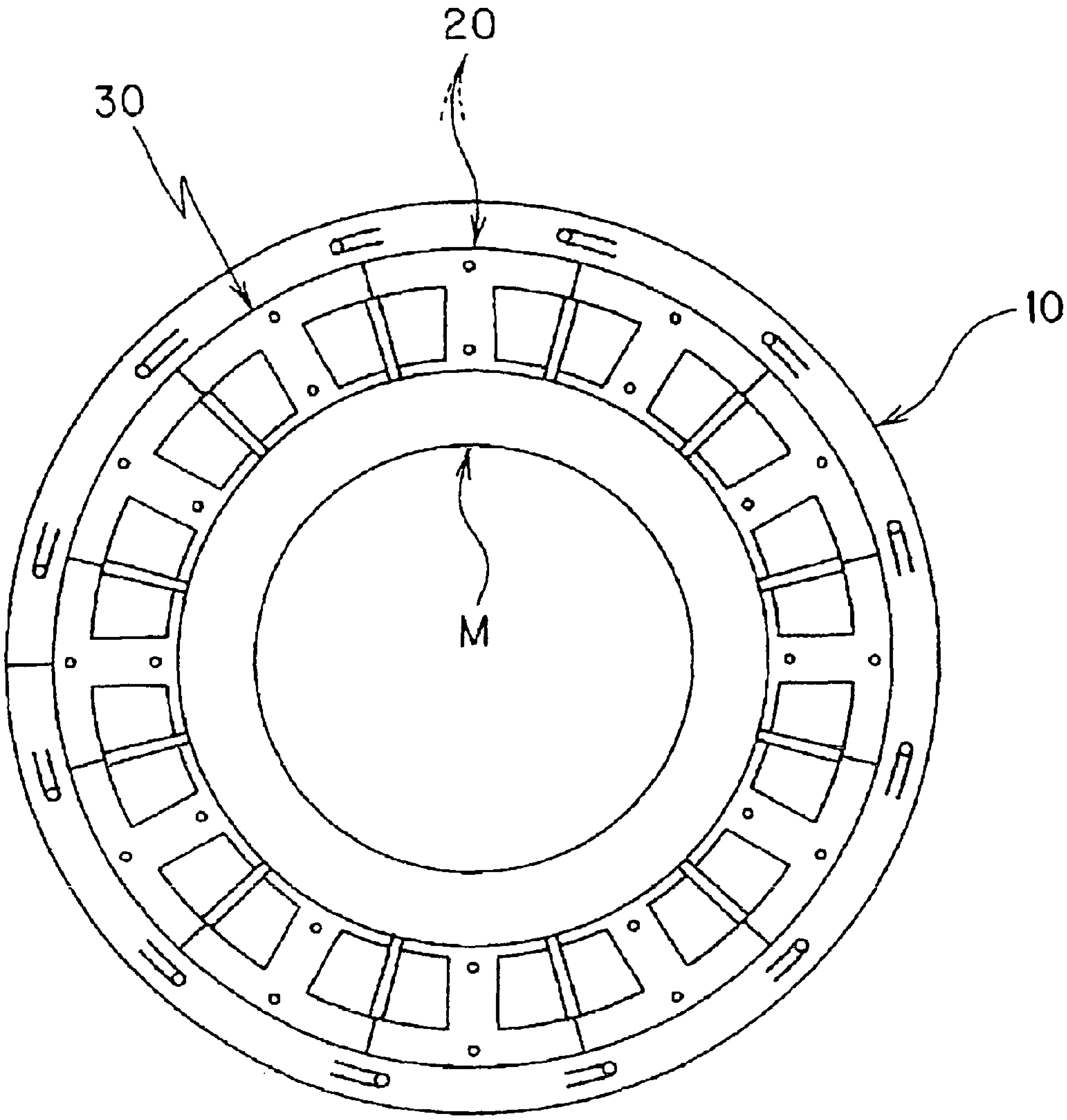


Fig. 36

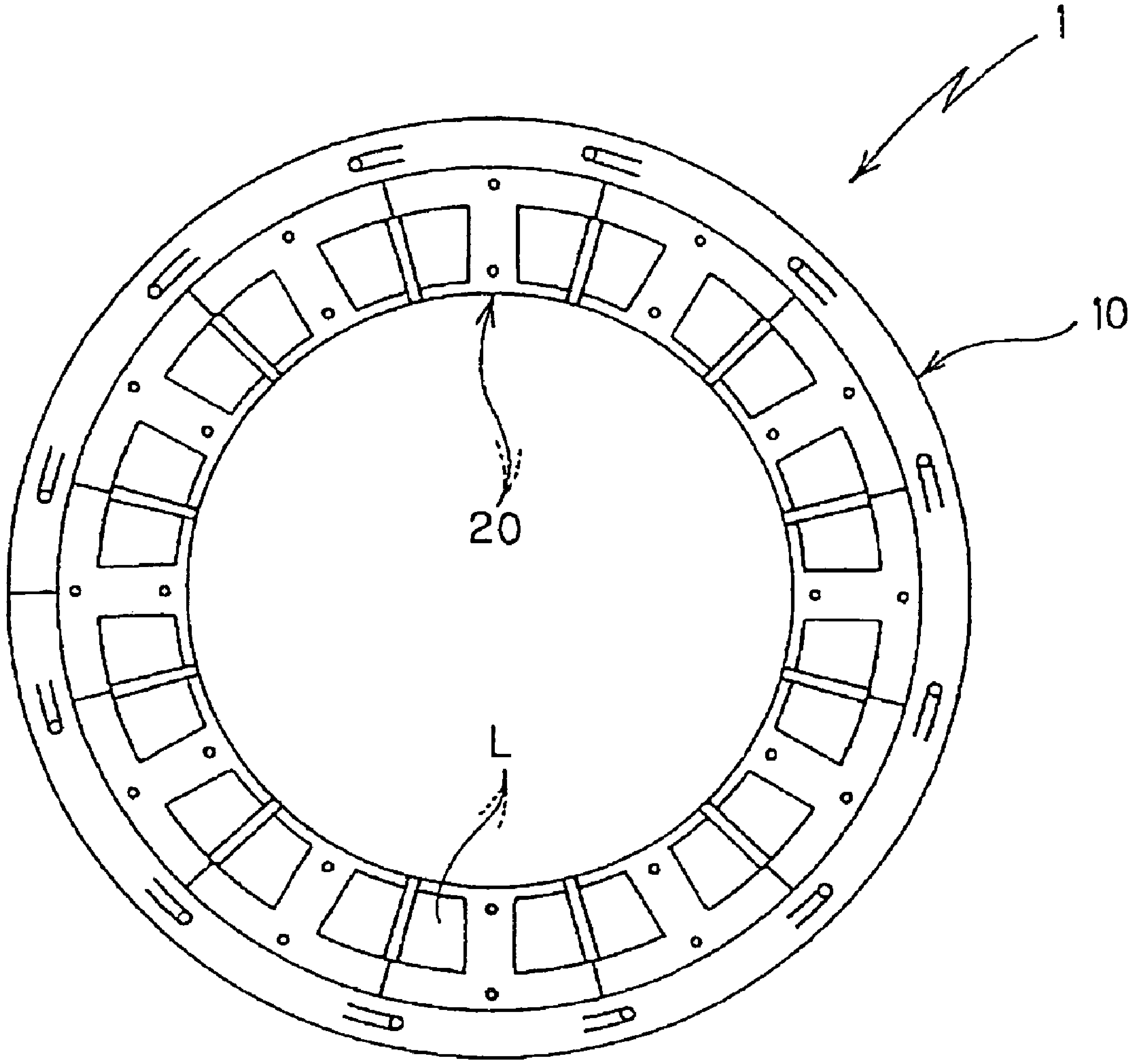


Fig. 37A

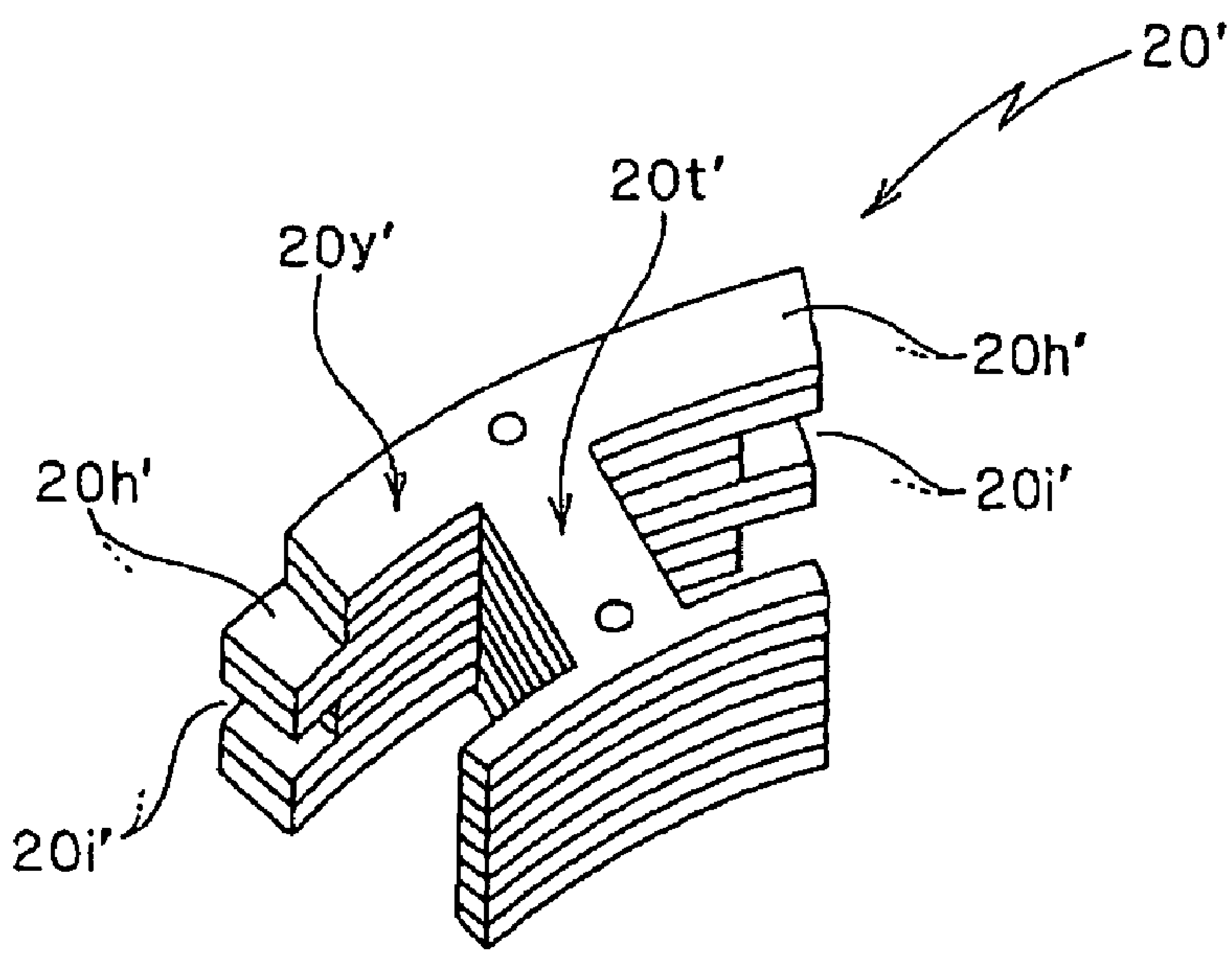
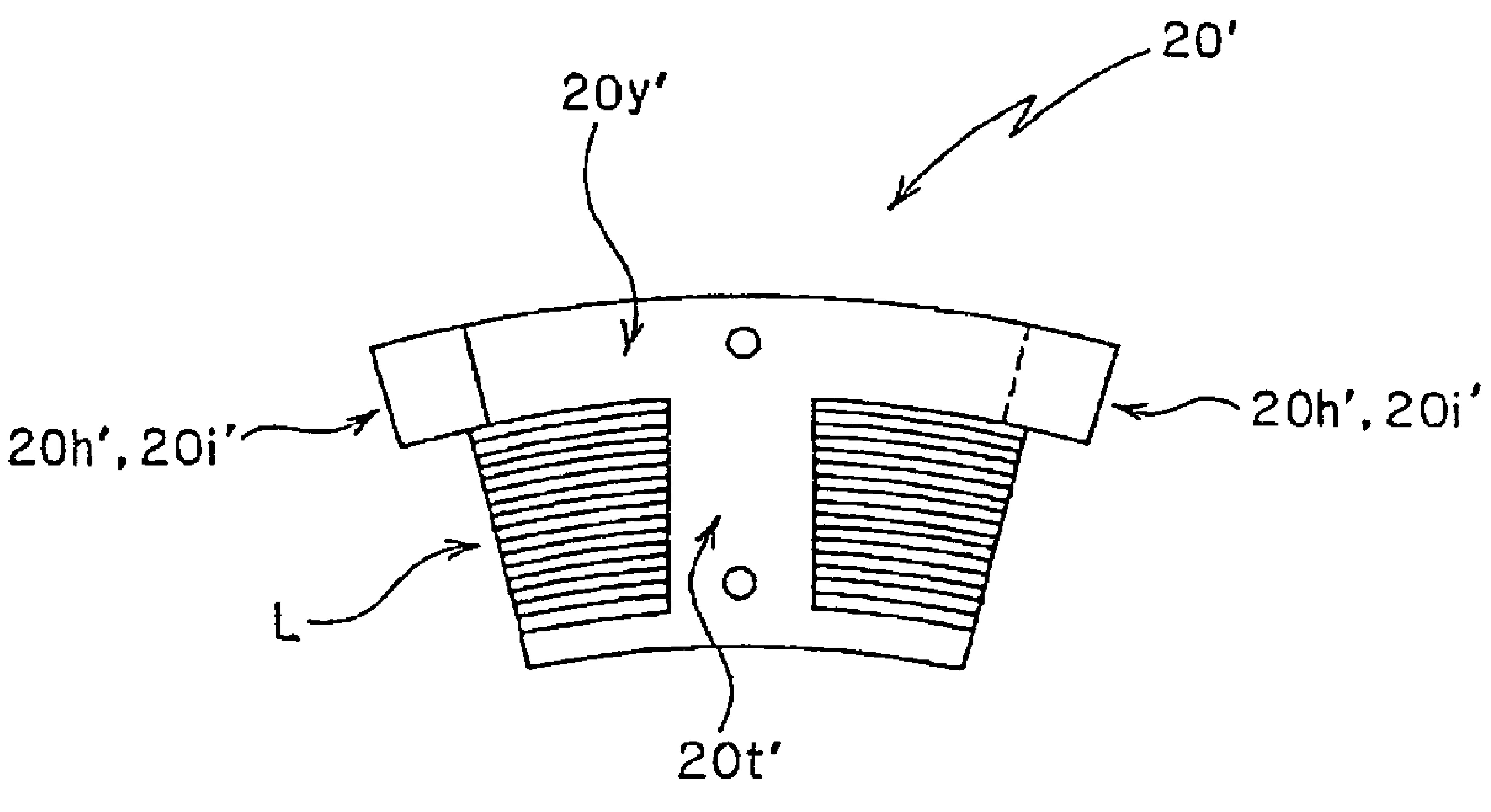


Fig. 37B



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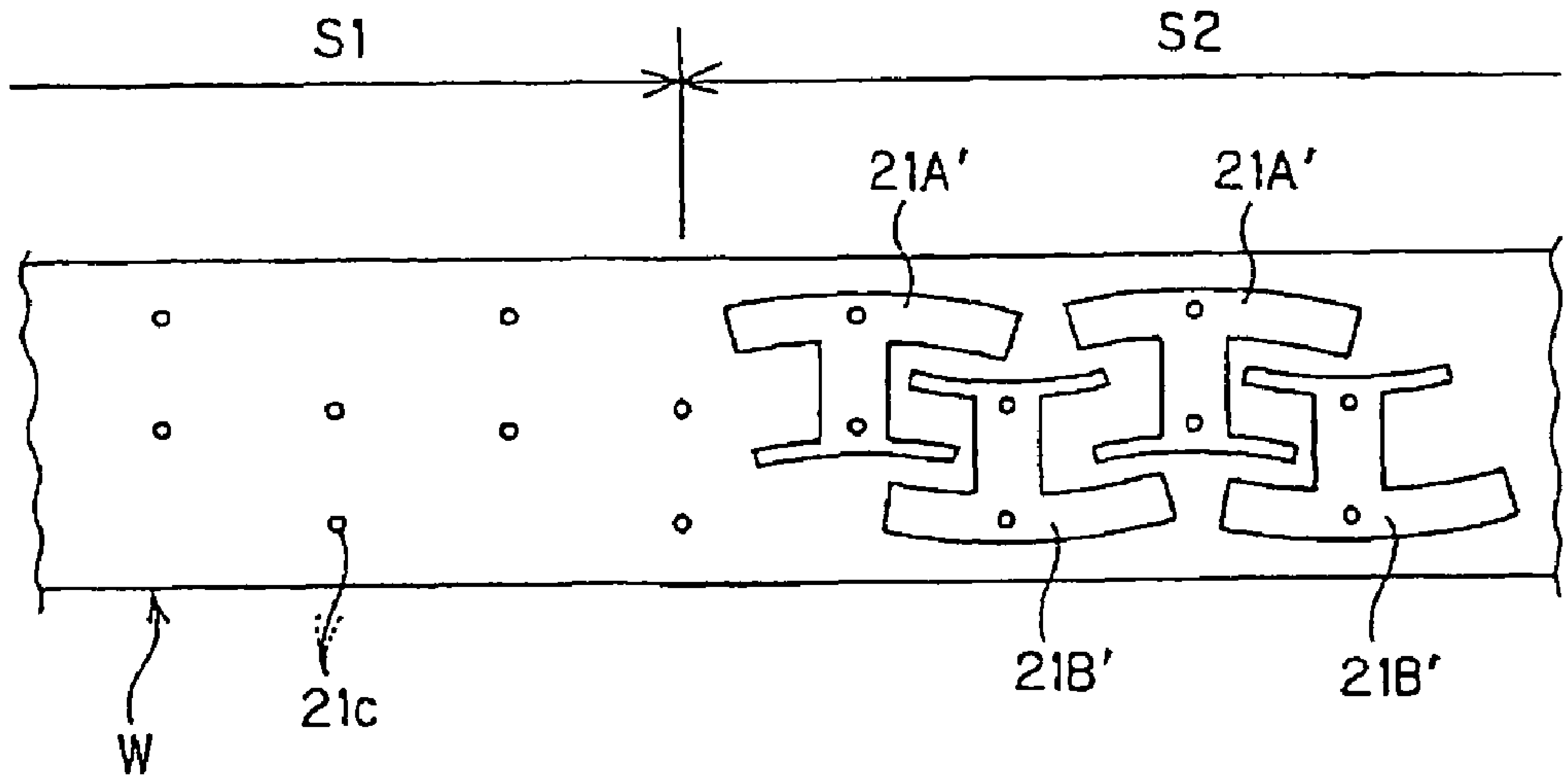


Fig. 38B

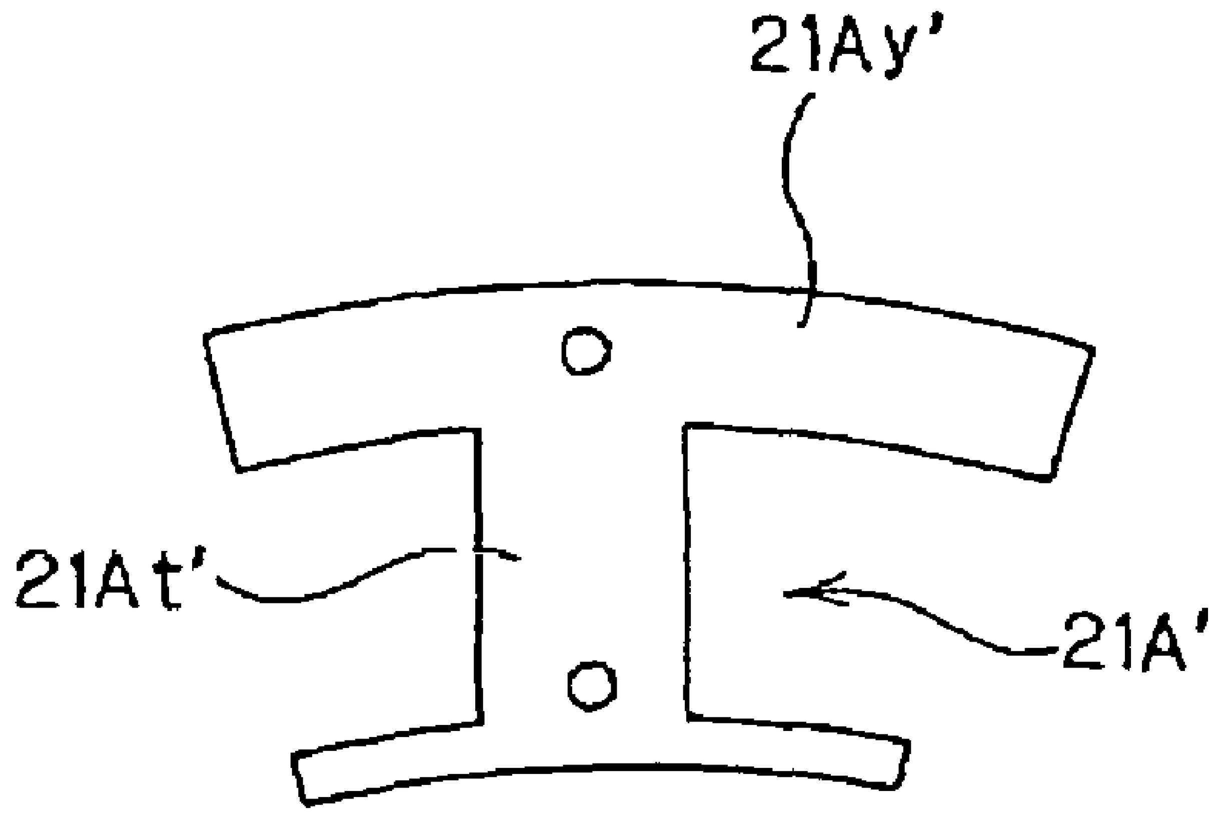


Fig. 38C

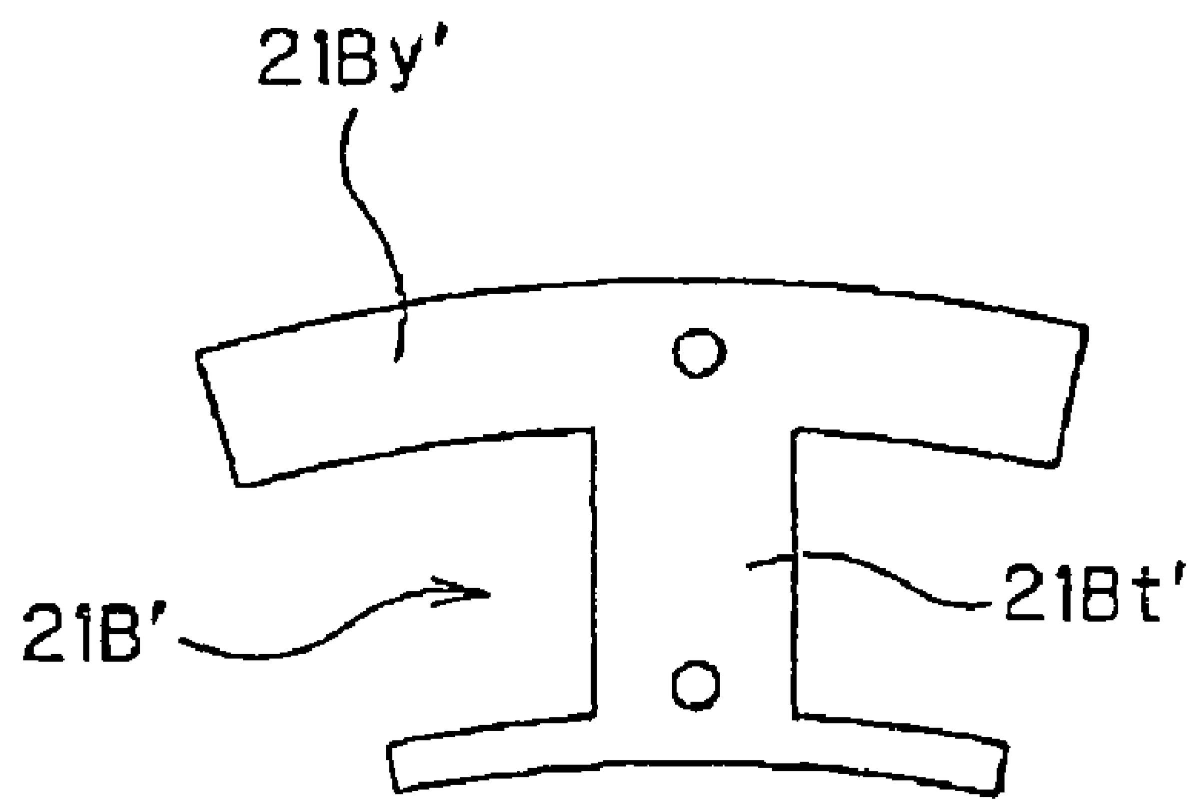


Fig. 39A

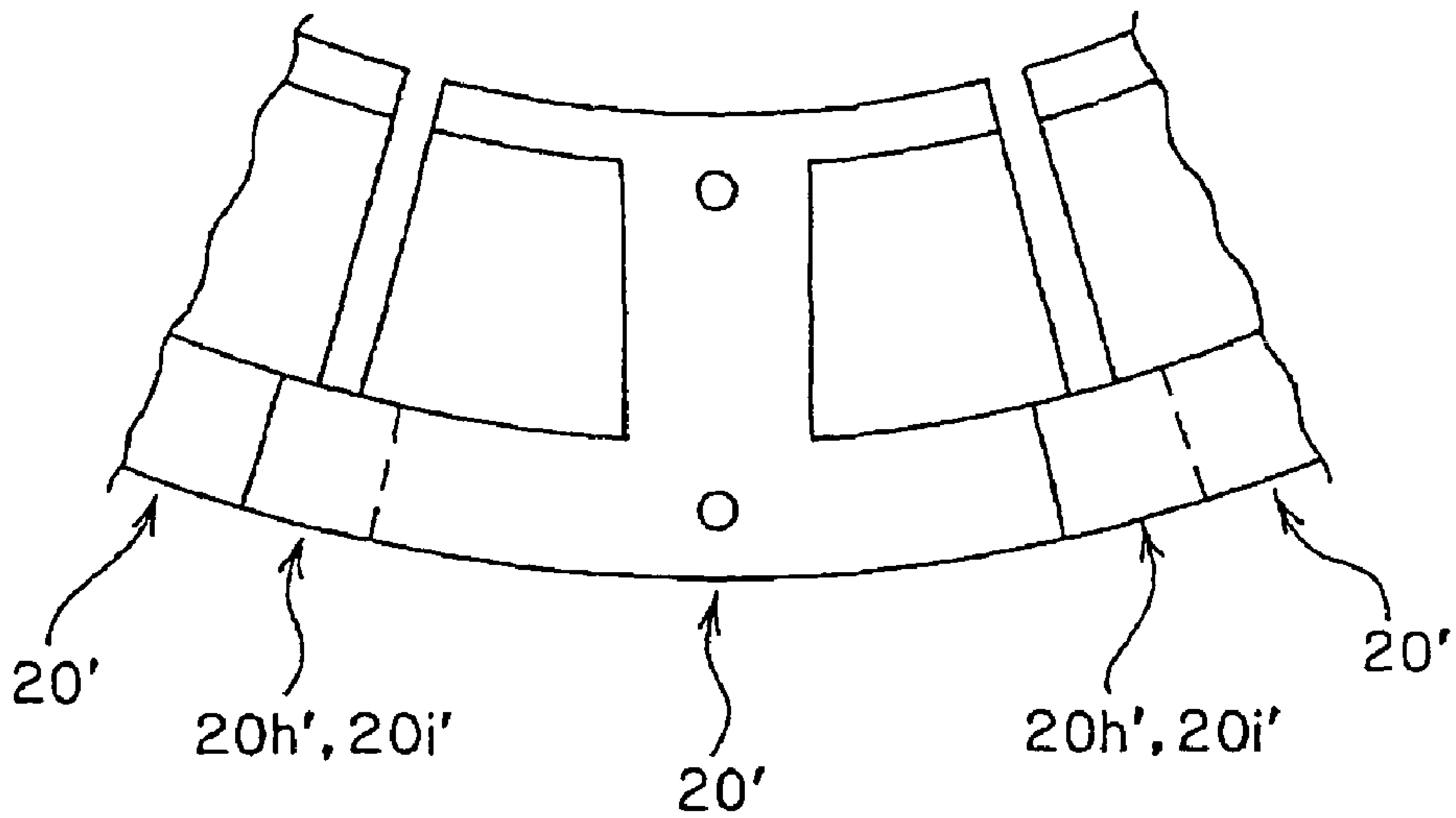


Fig. 39B

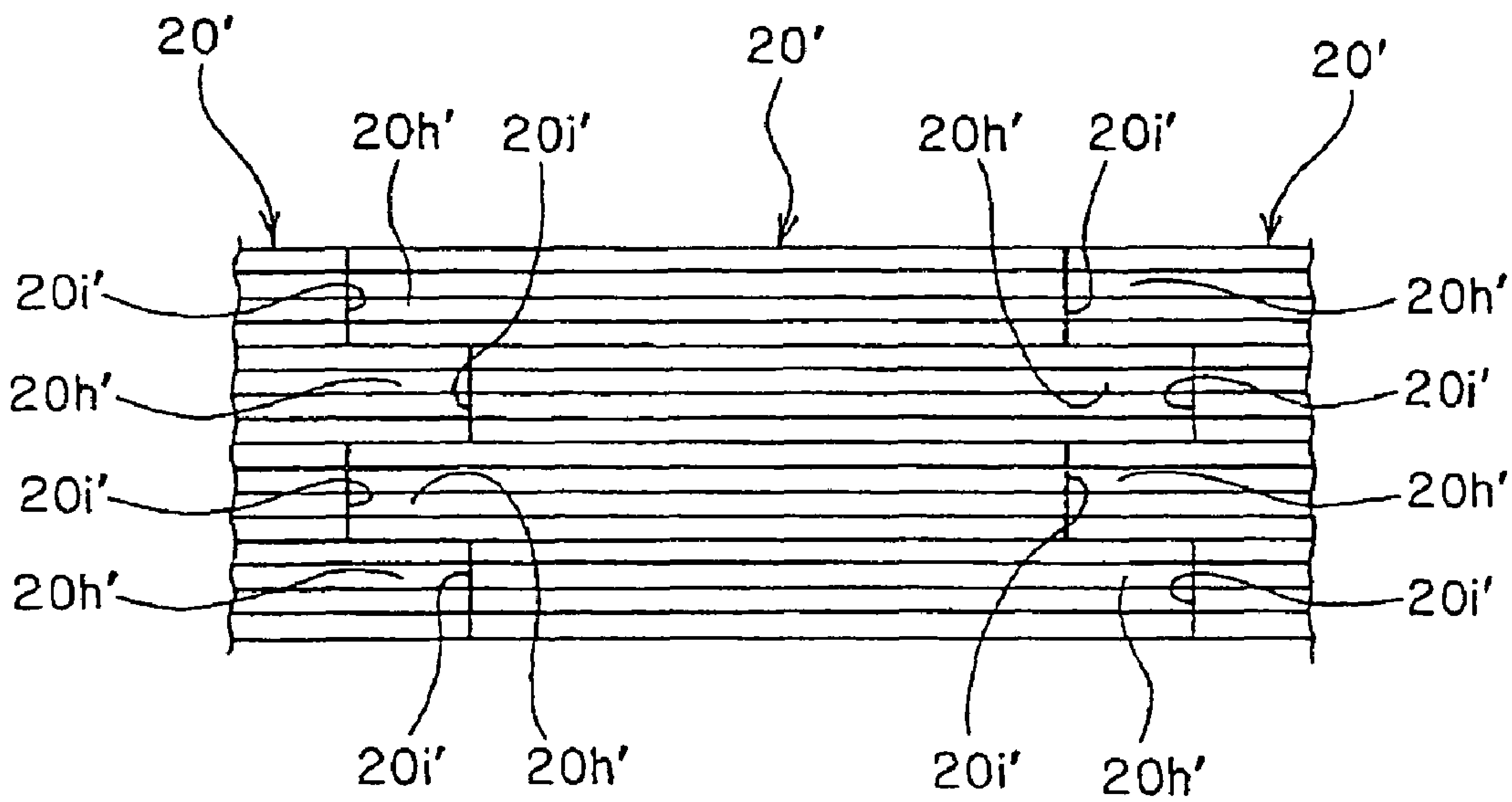


Fig. 40A

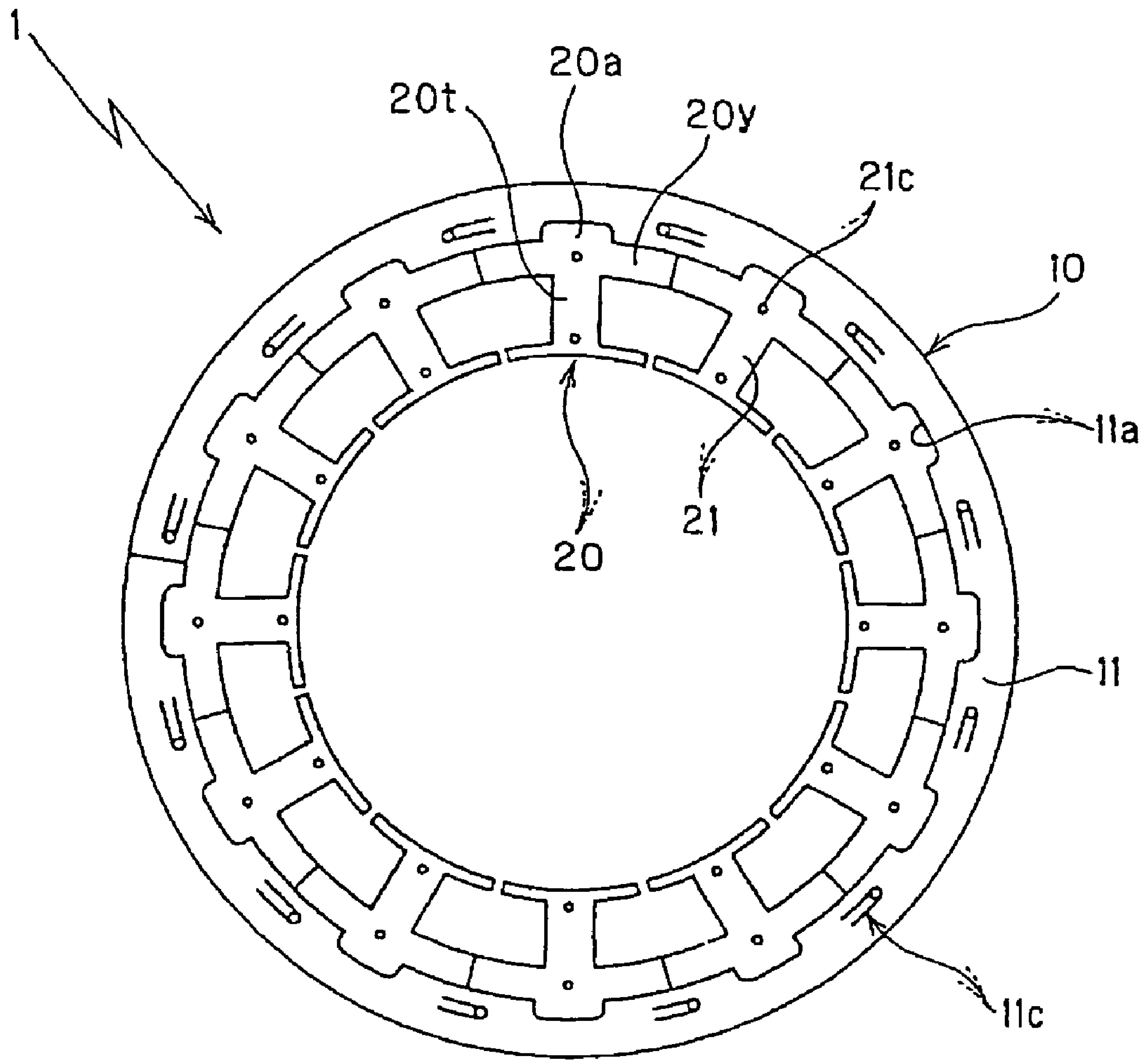


Fig. 40B

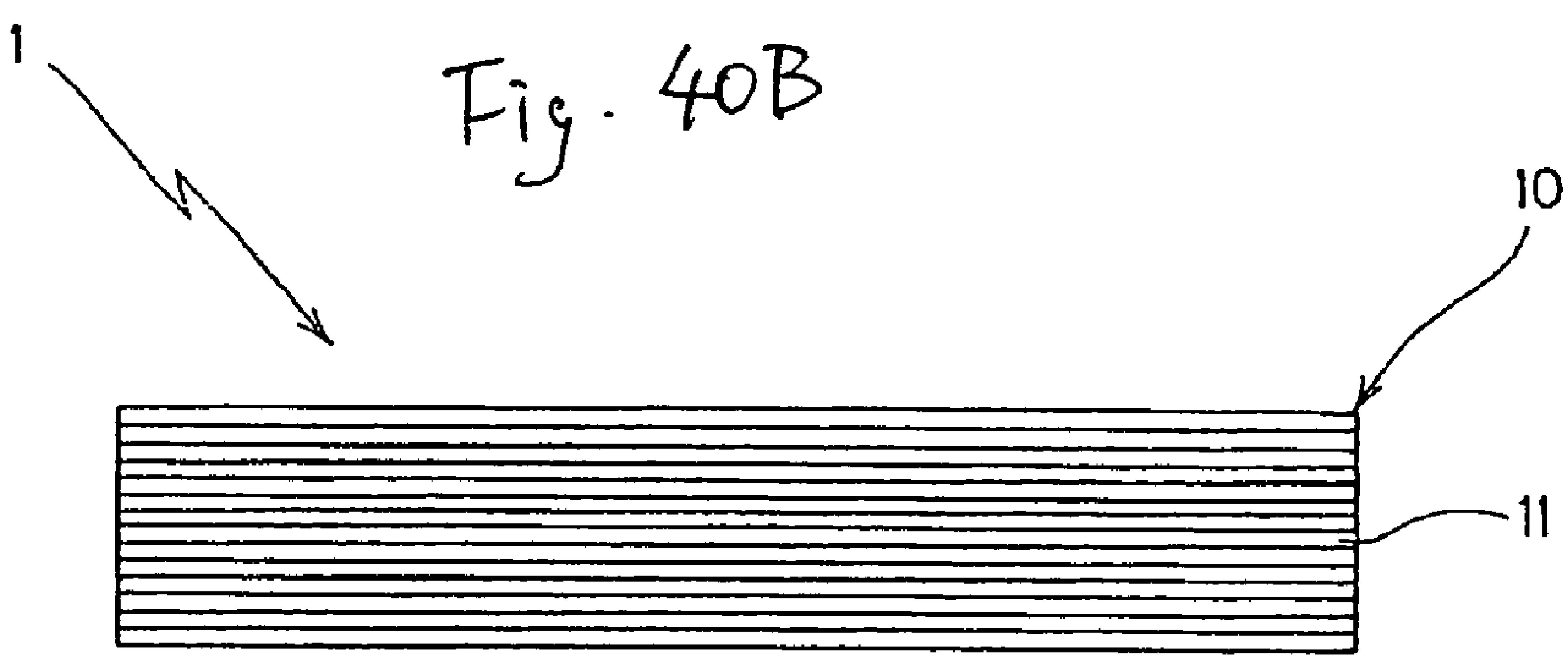


Fig. 41A

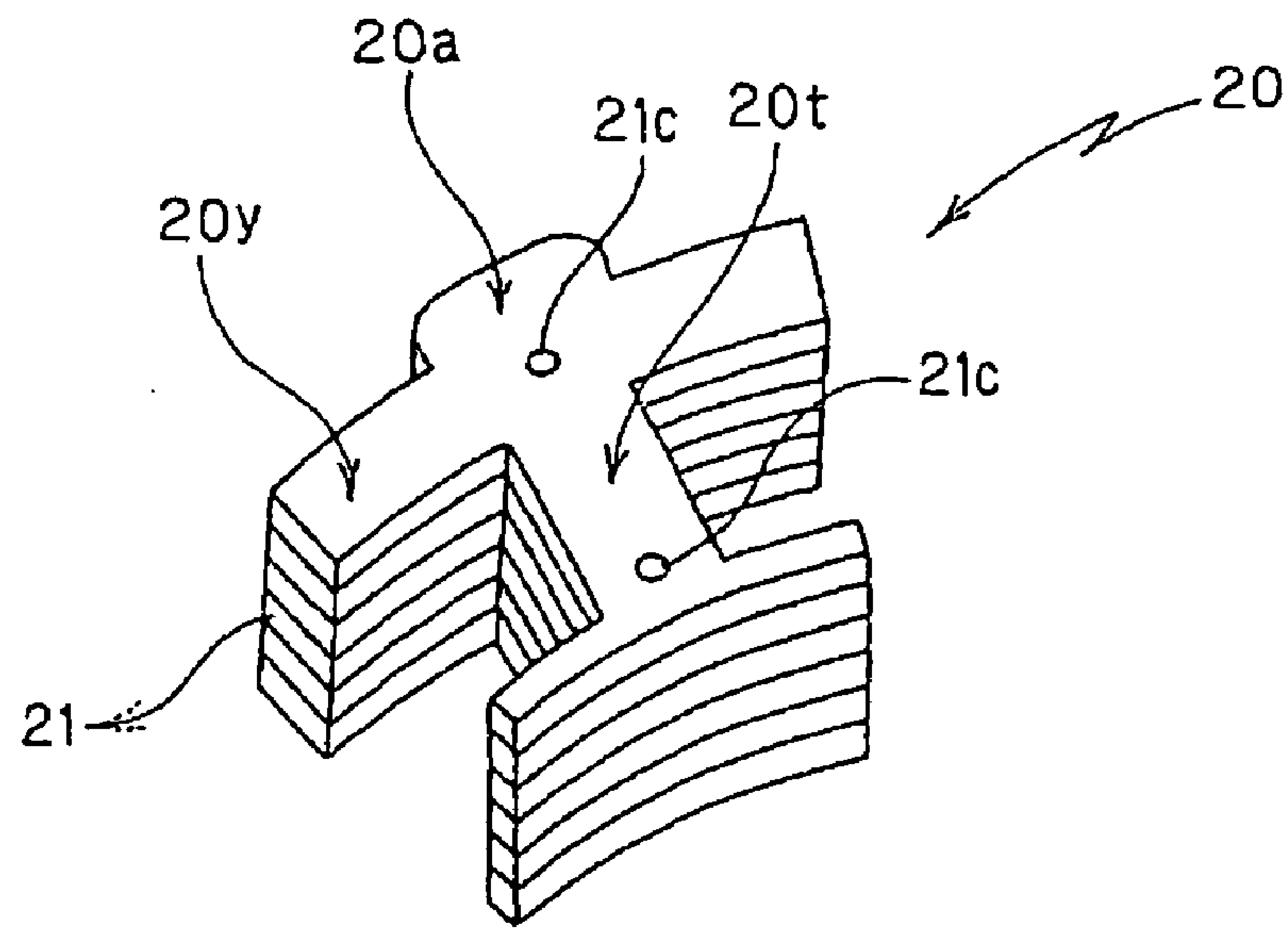


Fig. 41B

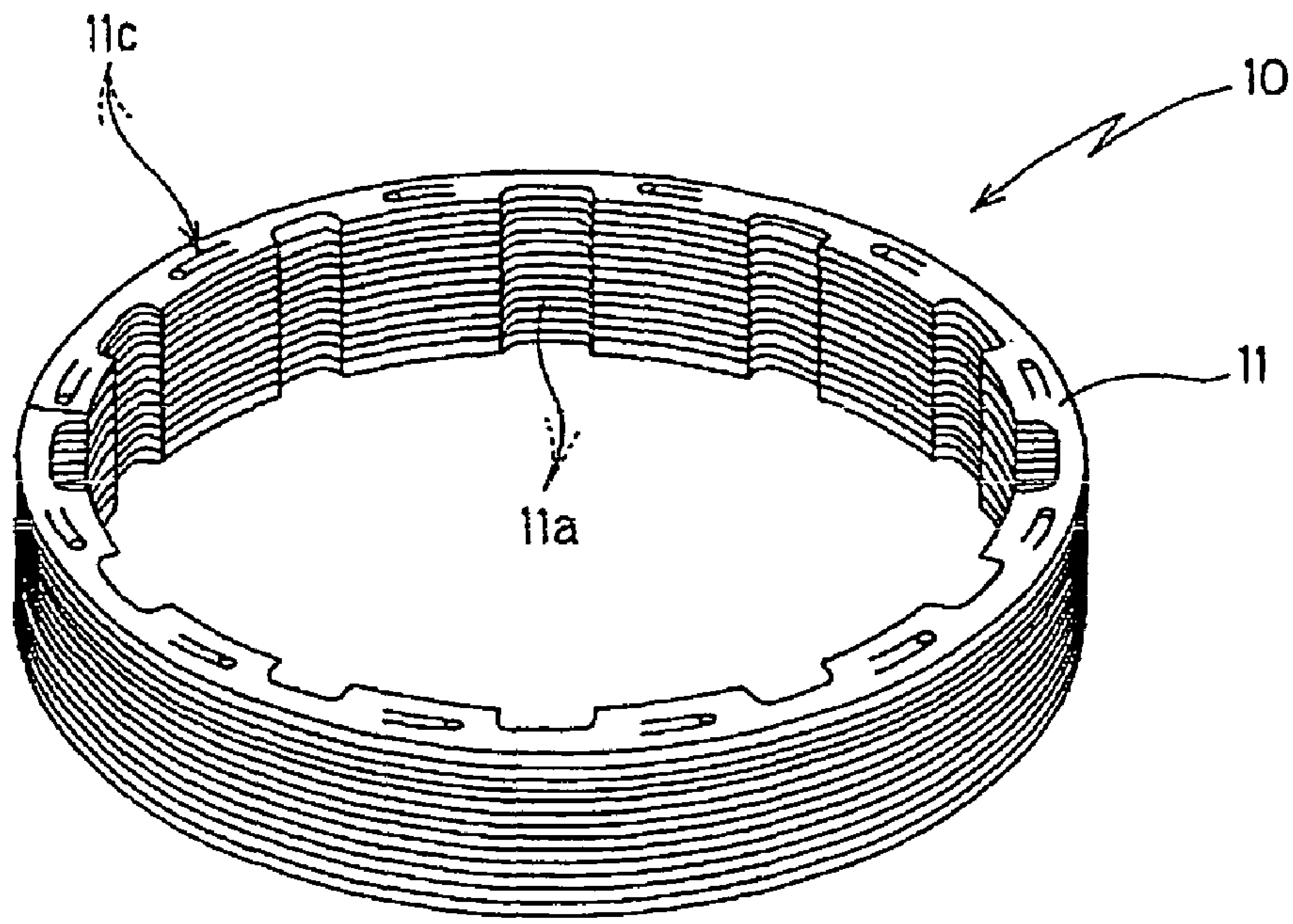


Fig. 42A

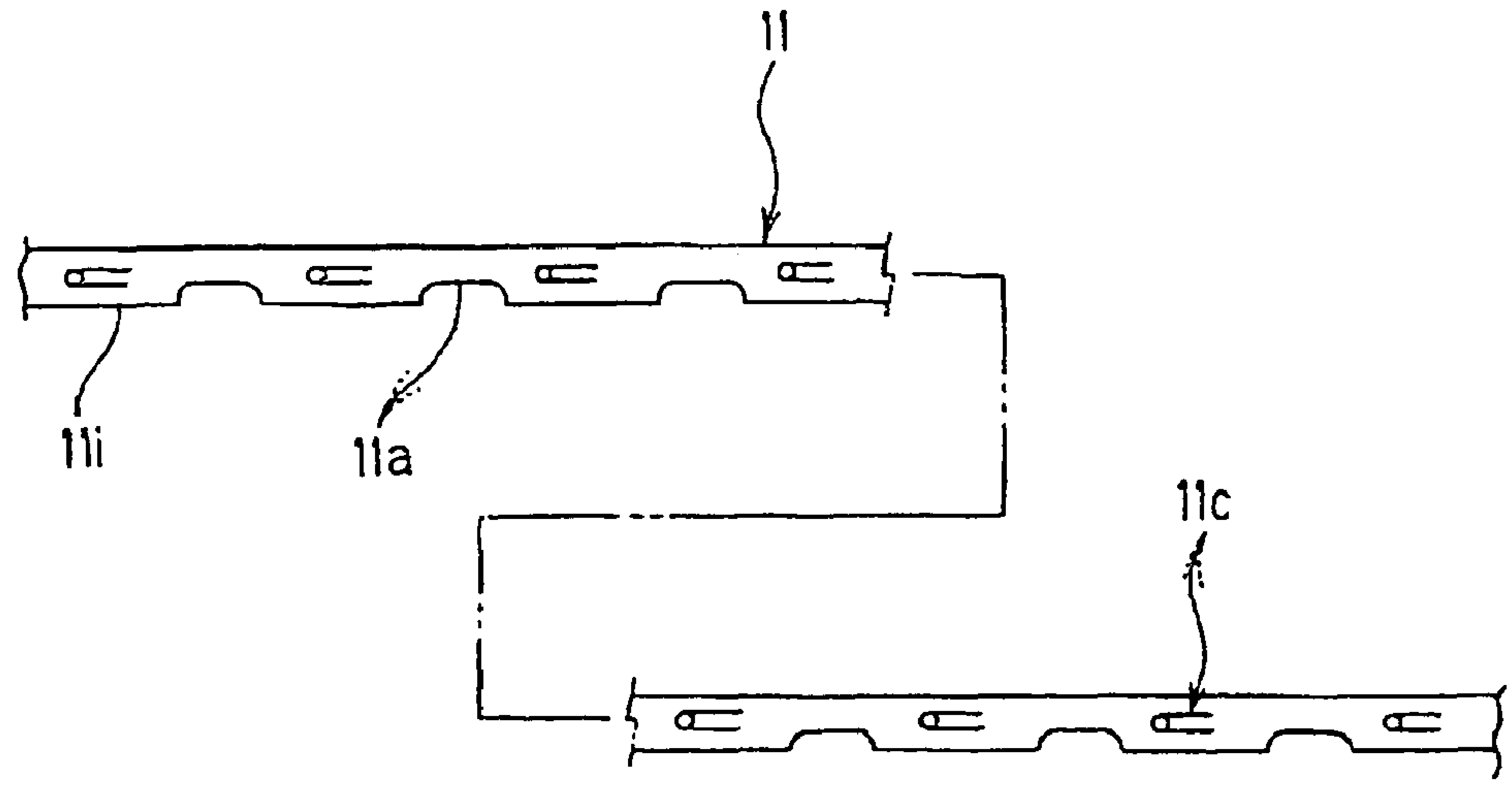


Fig. 42B

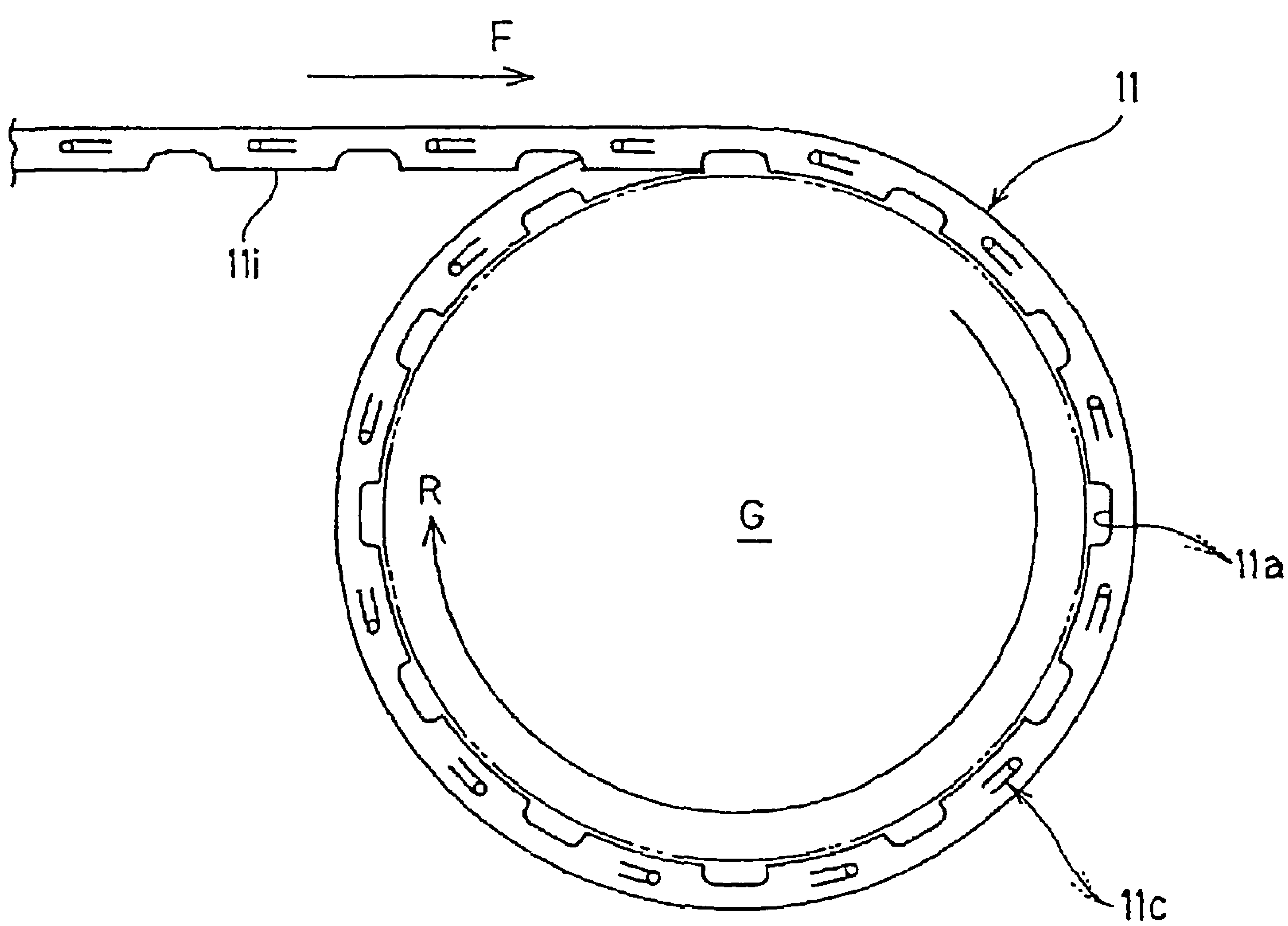


Fig. 43A

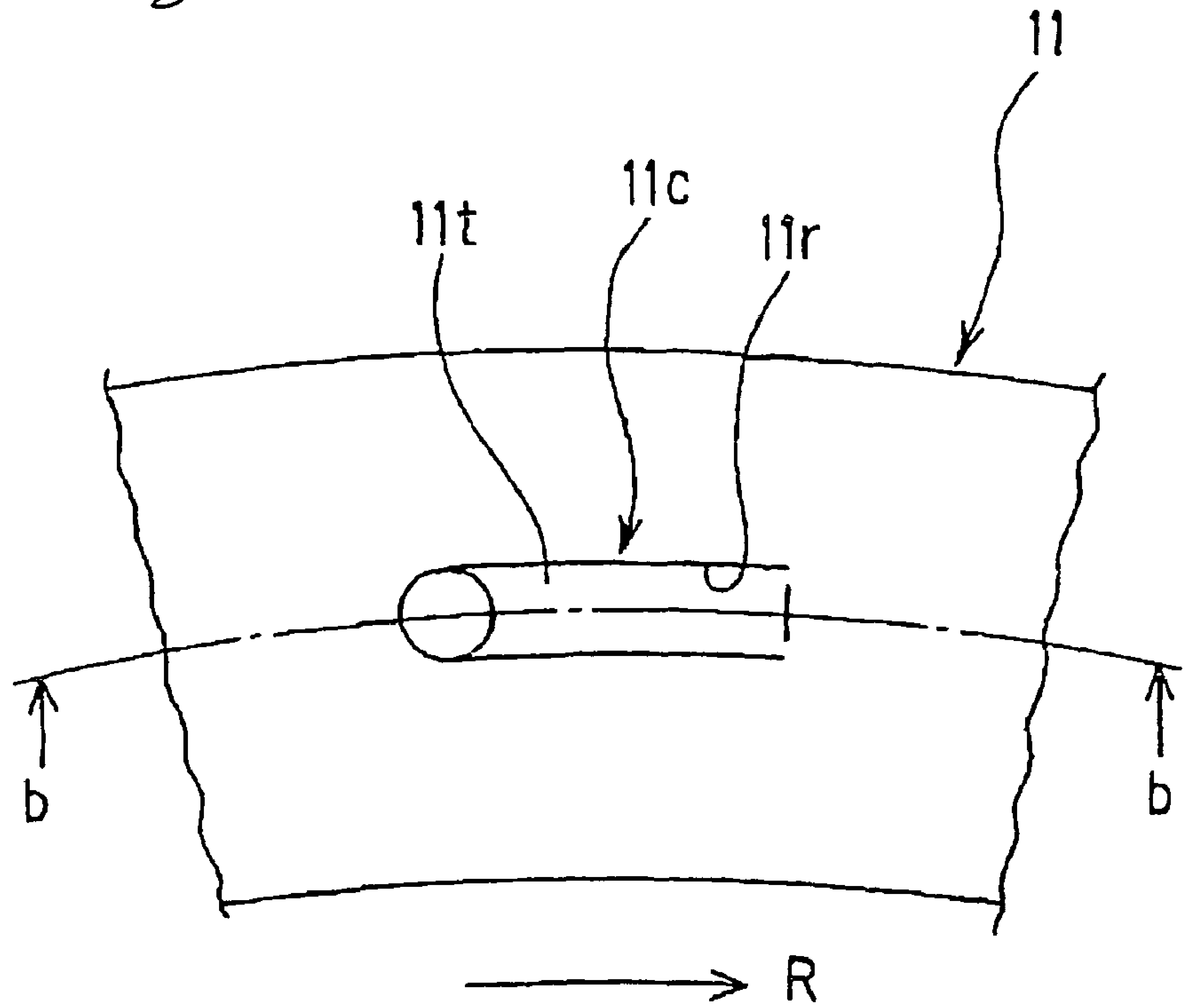


Fig. 43B

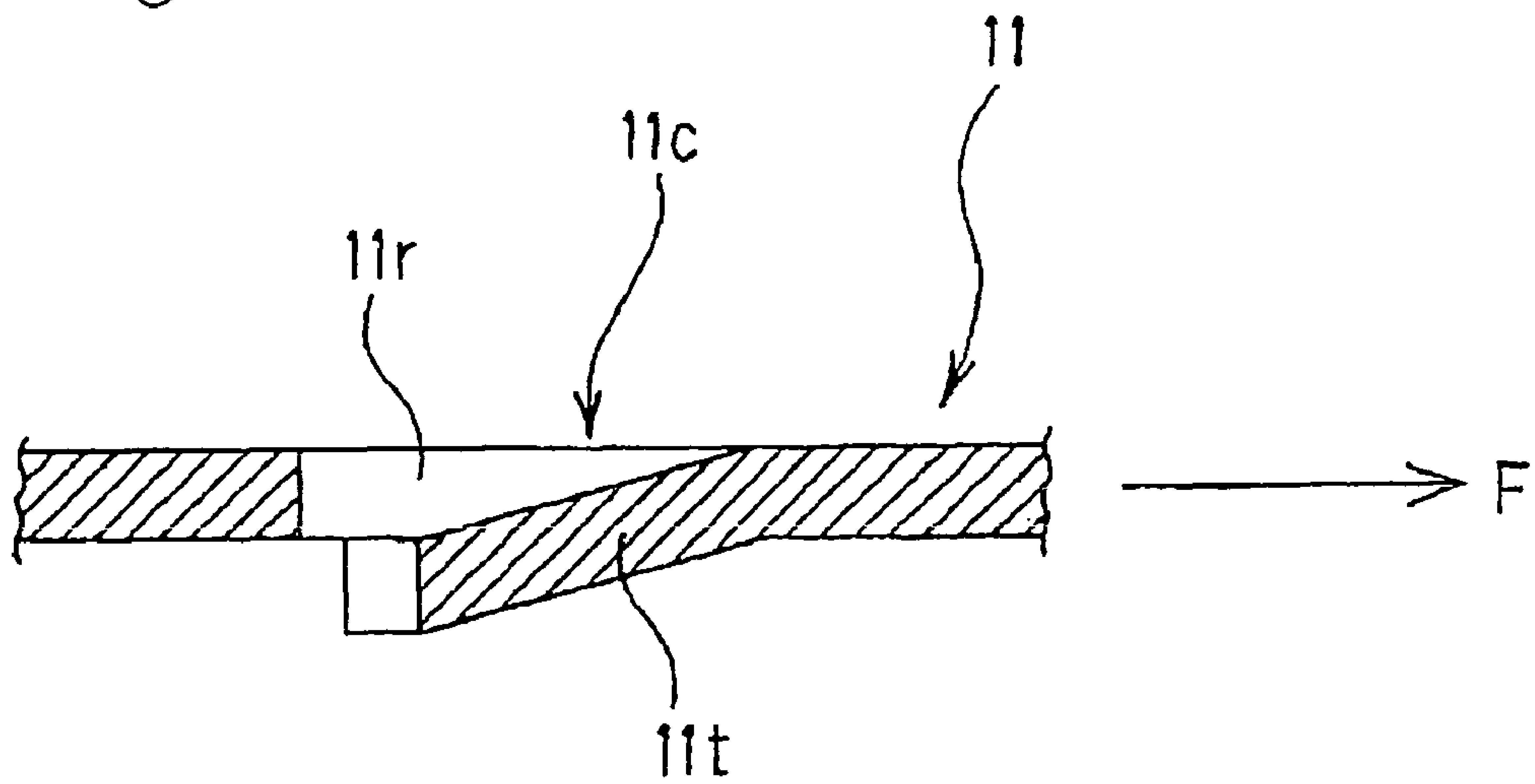


Fig. 44A

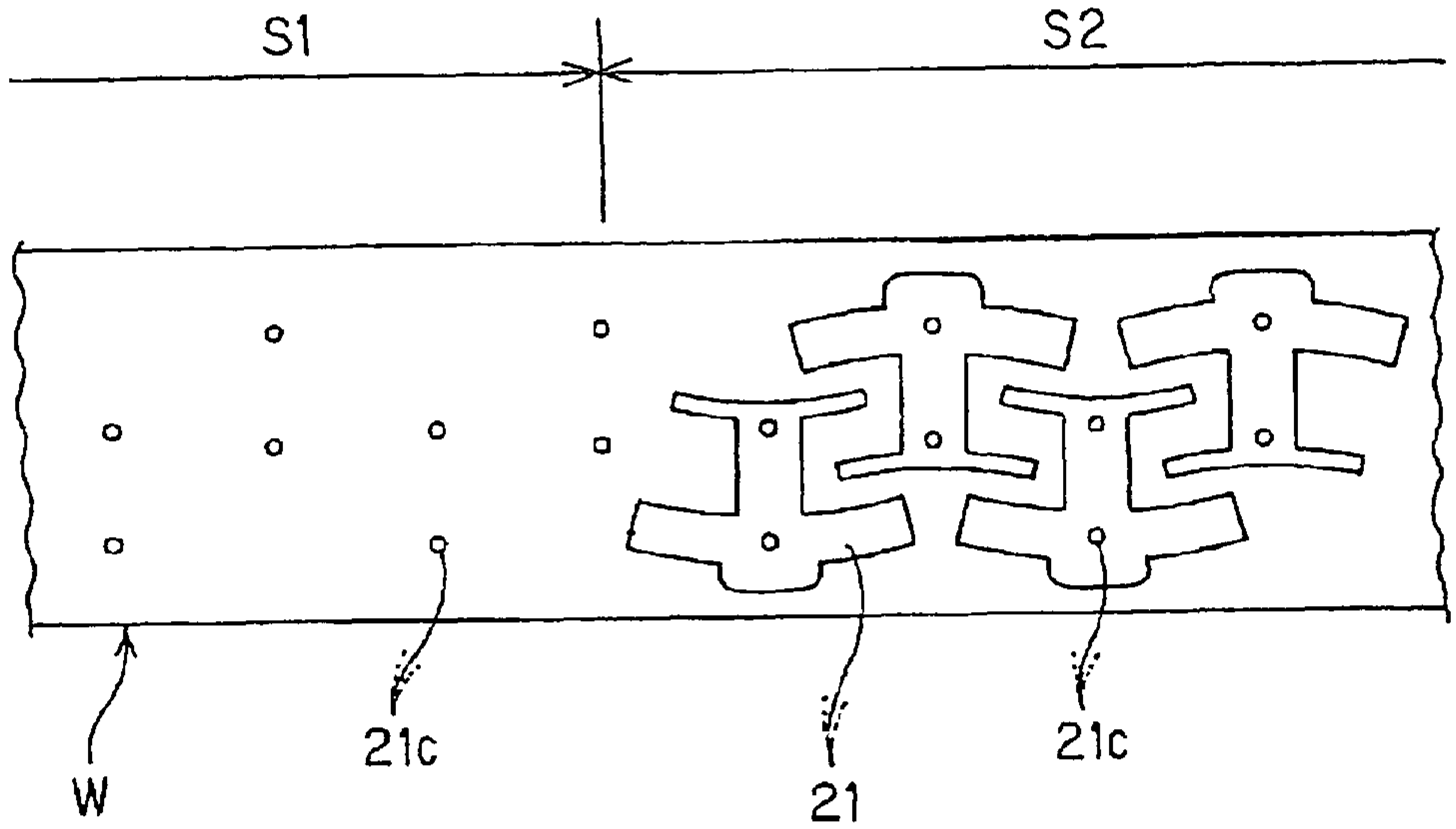


Fig. 44B

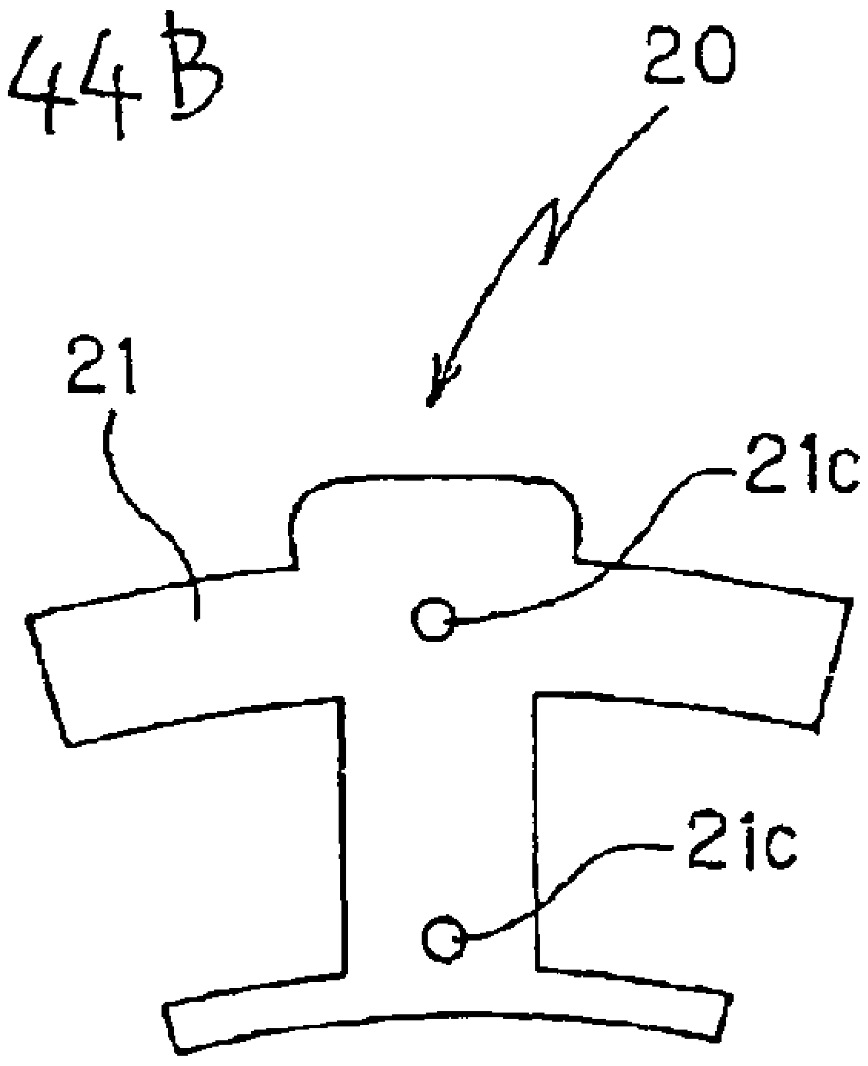


Fig. 44C

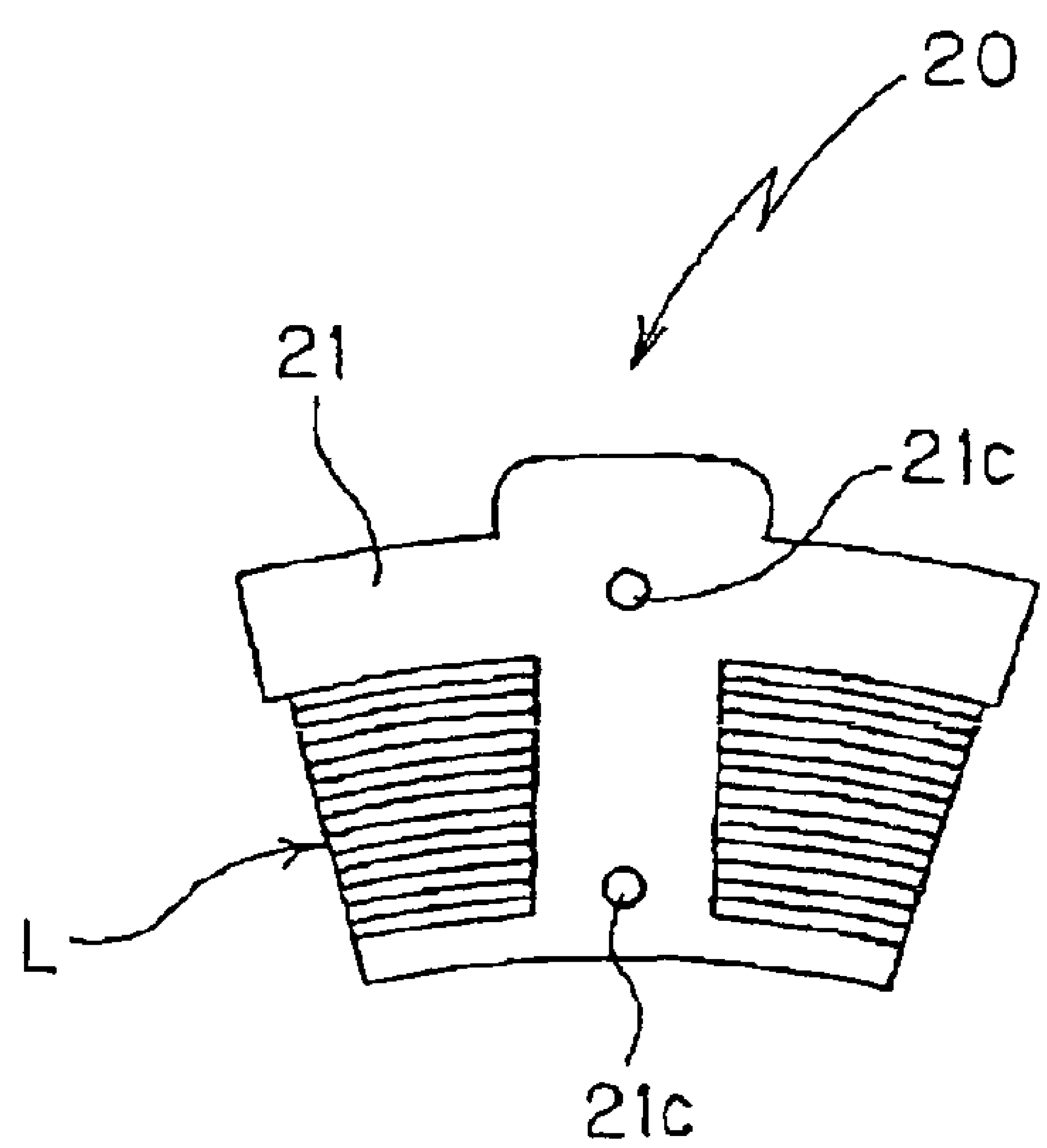


Fig. 45

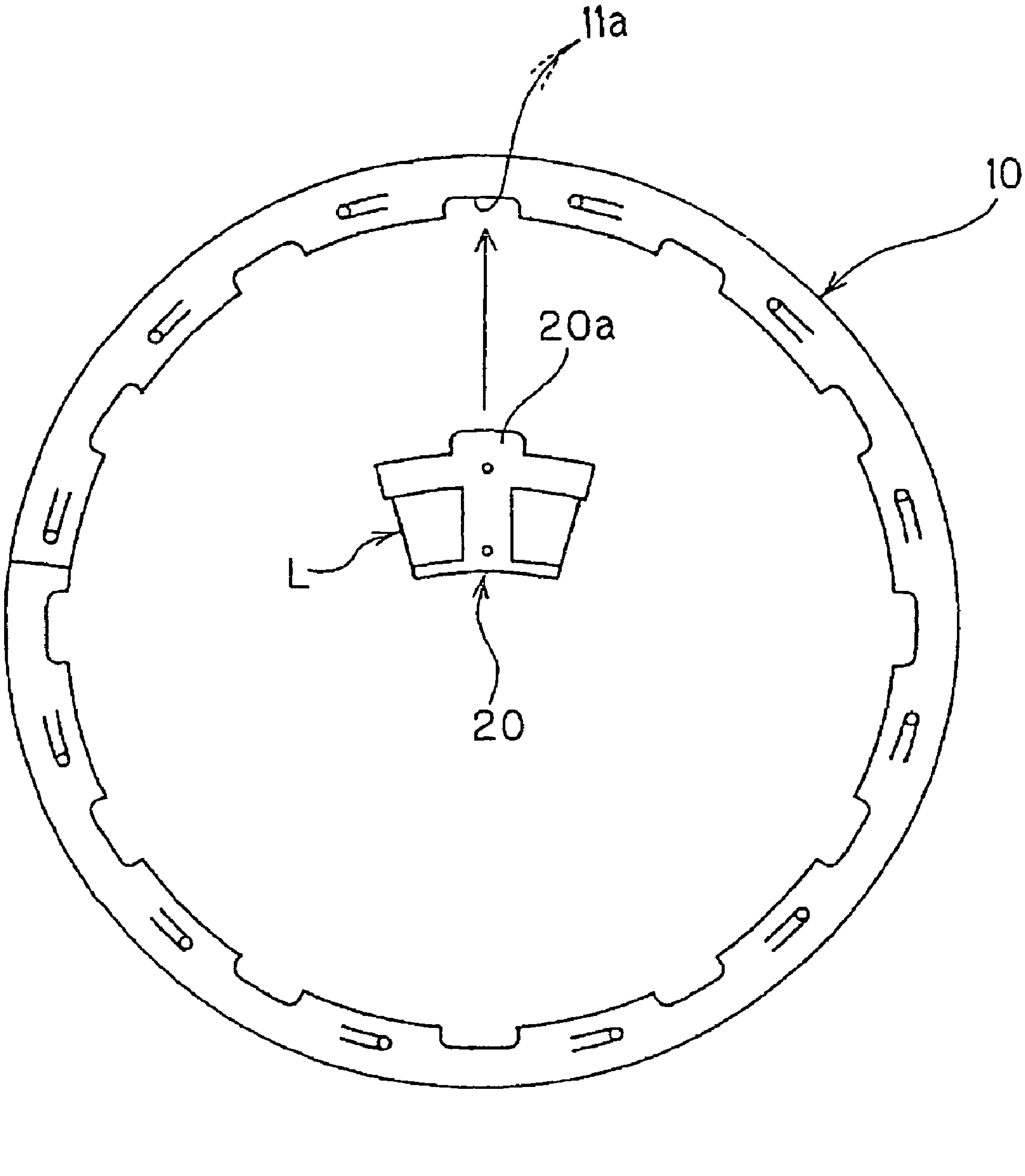


Fig. 46

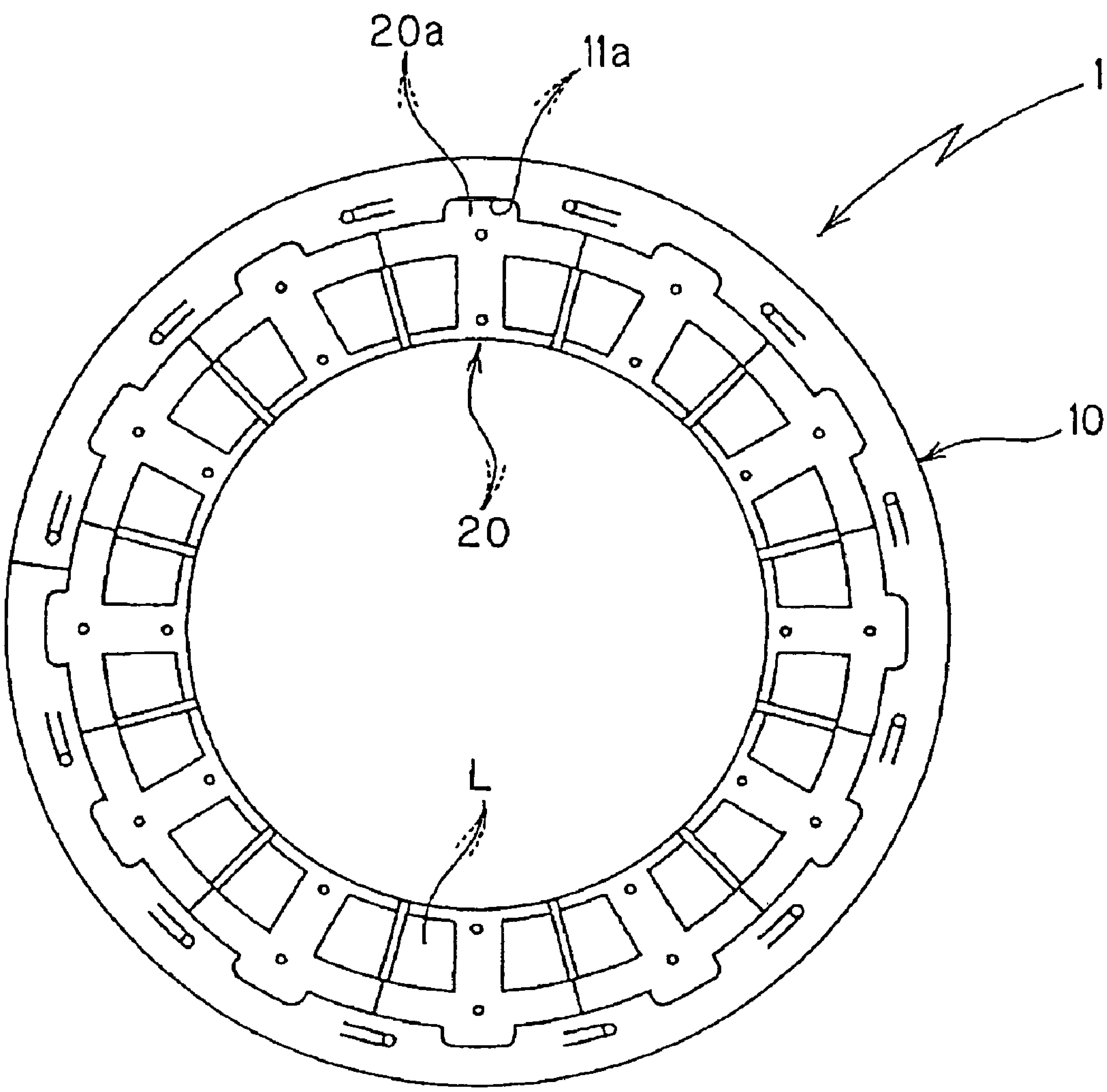


Fig. 47

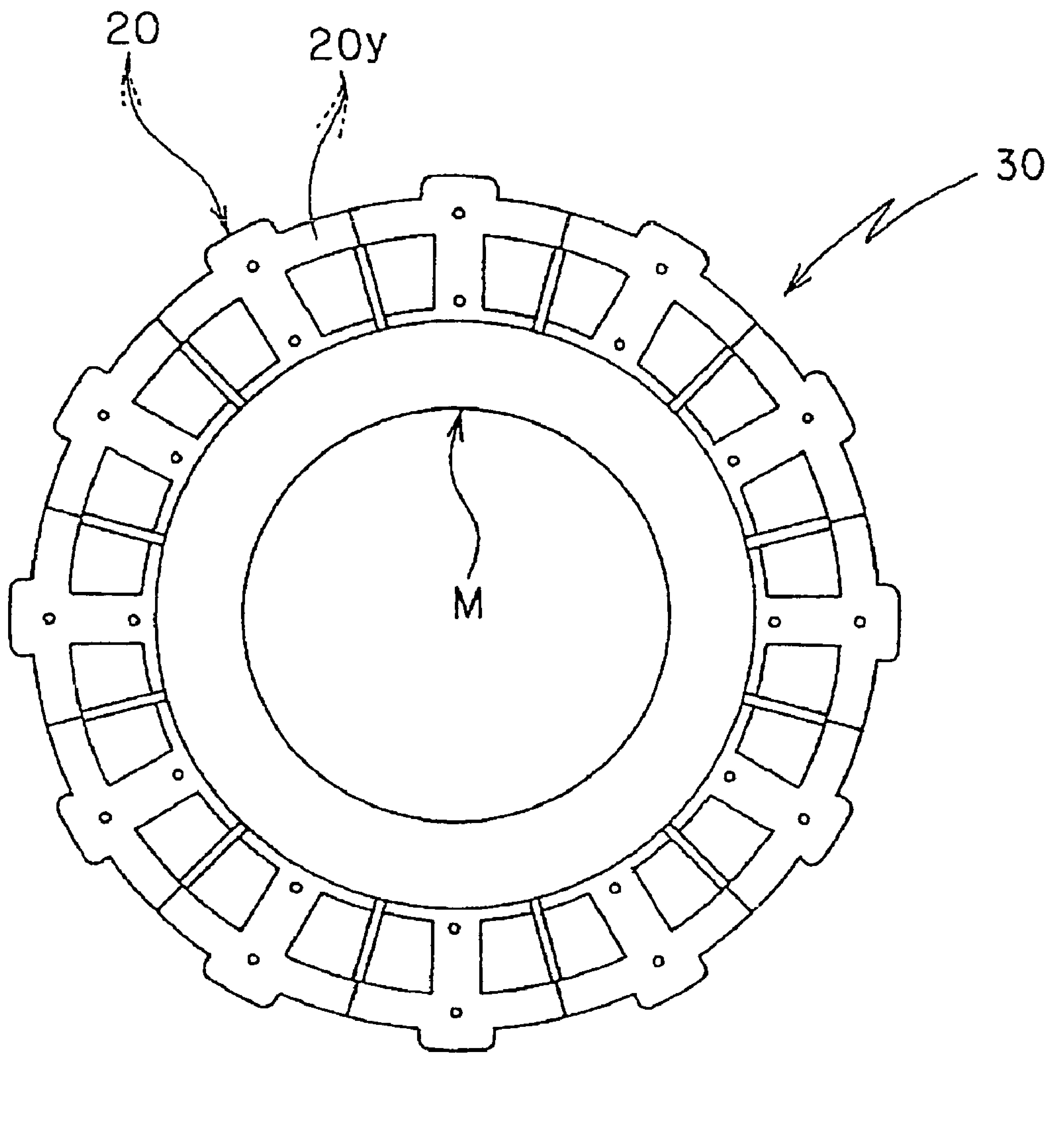


Fig. 48

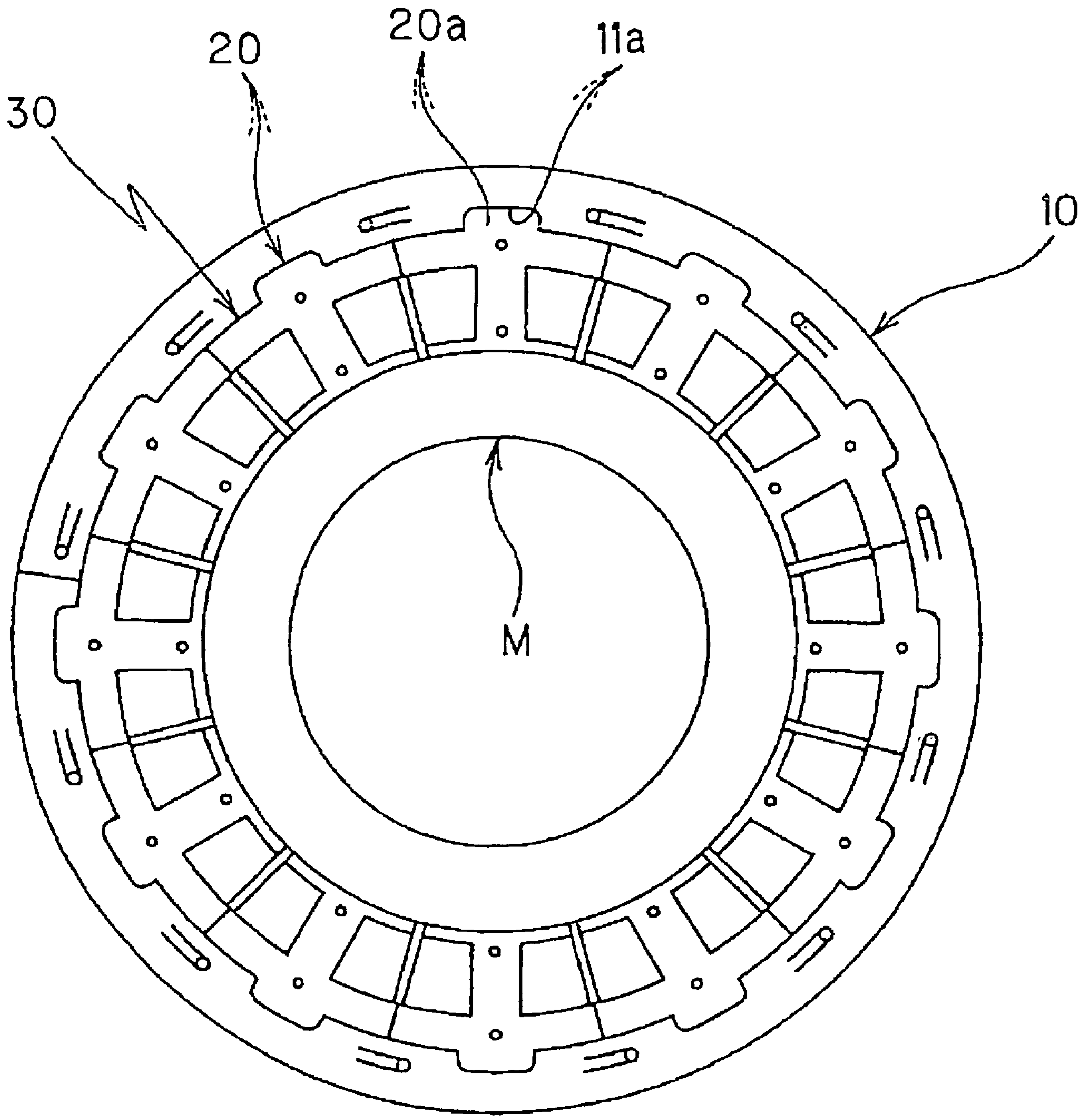


Fig. 49A

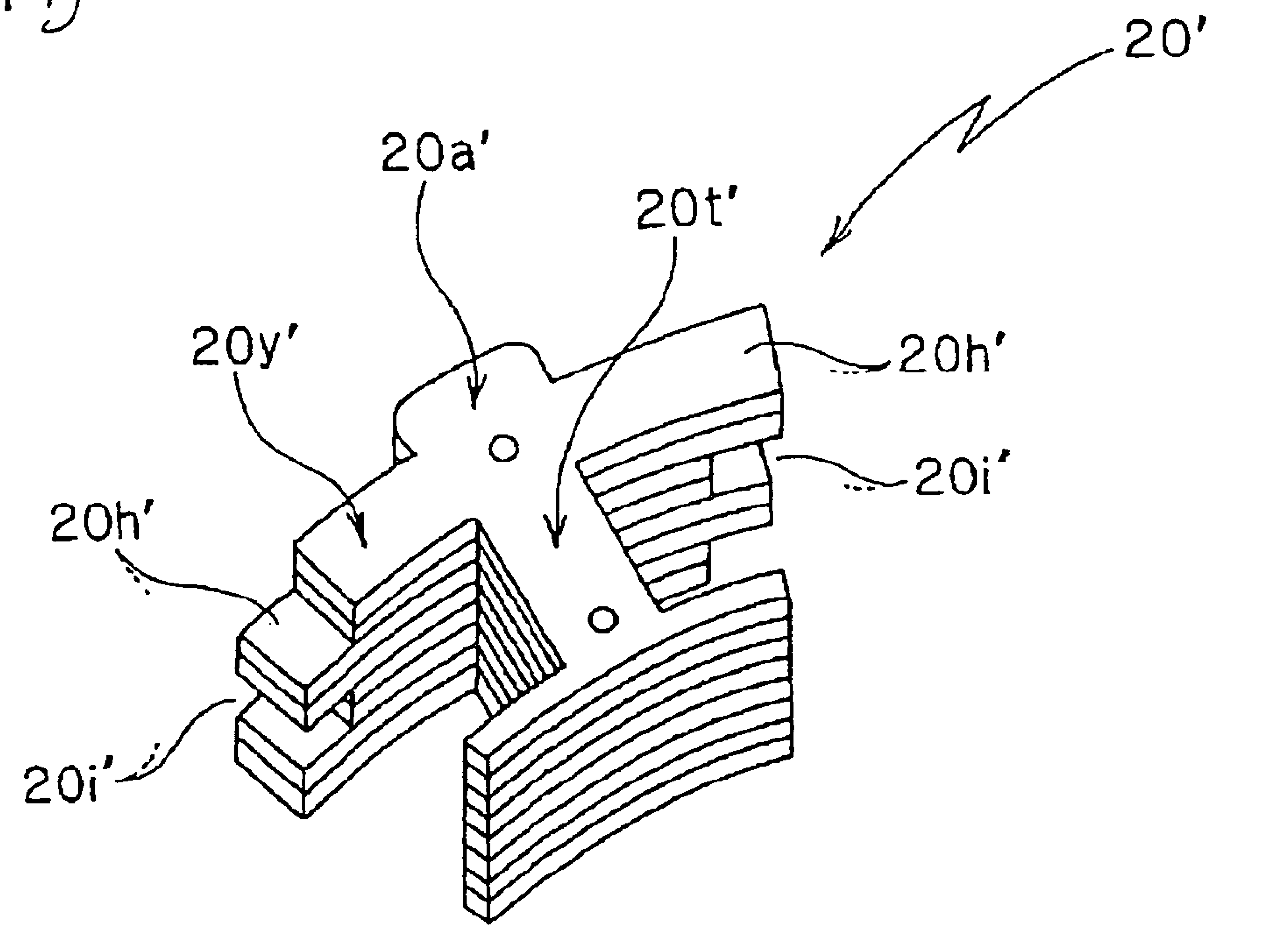


Fig. 49B

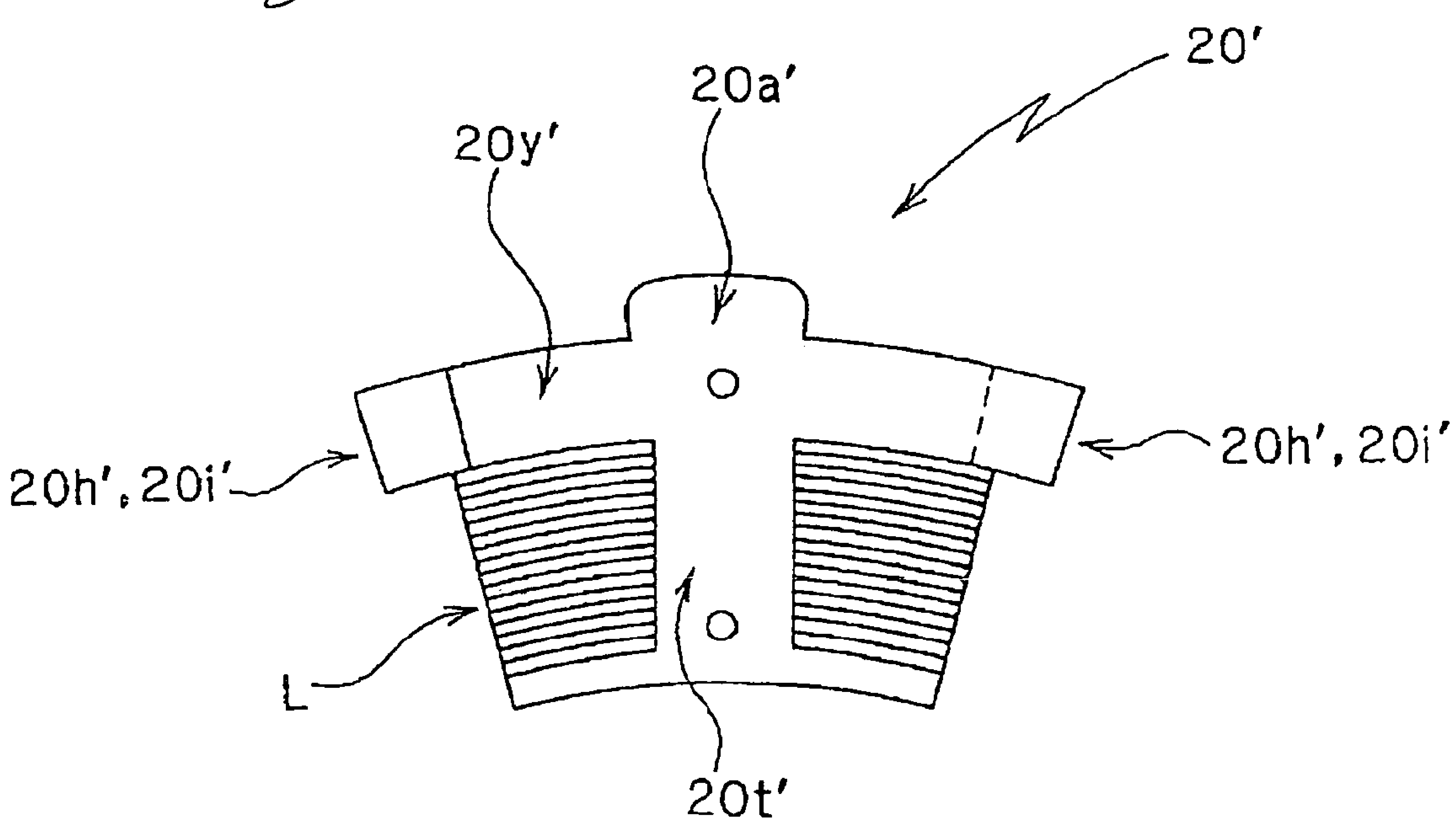


Fig. 50A

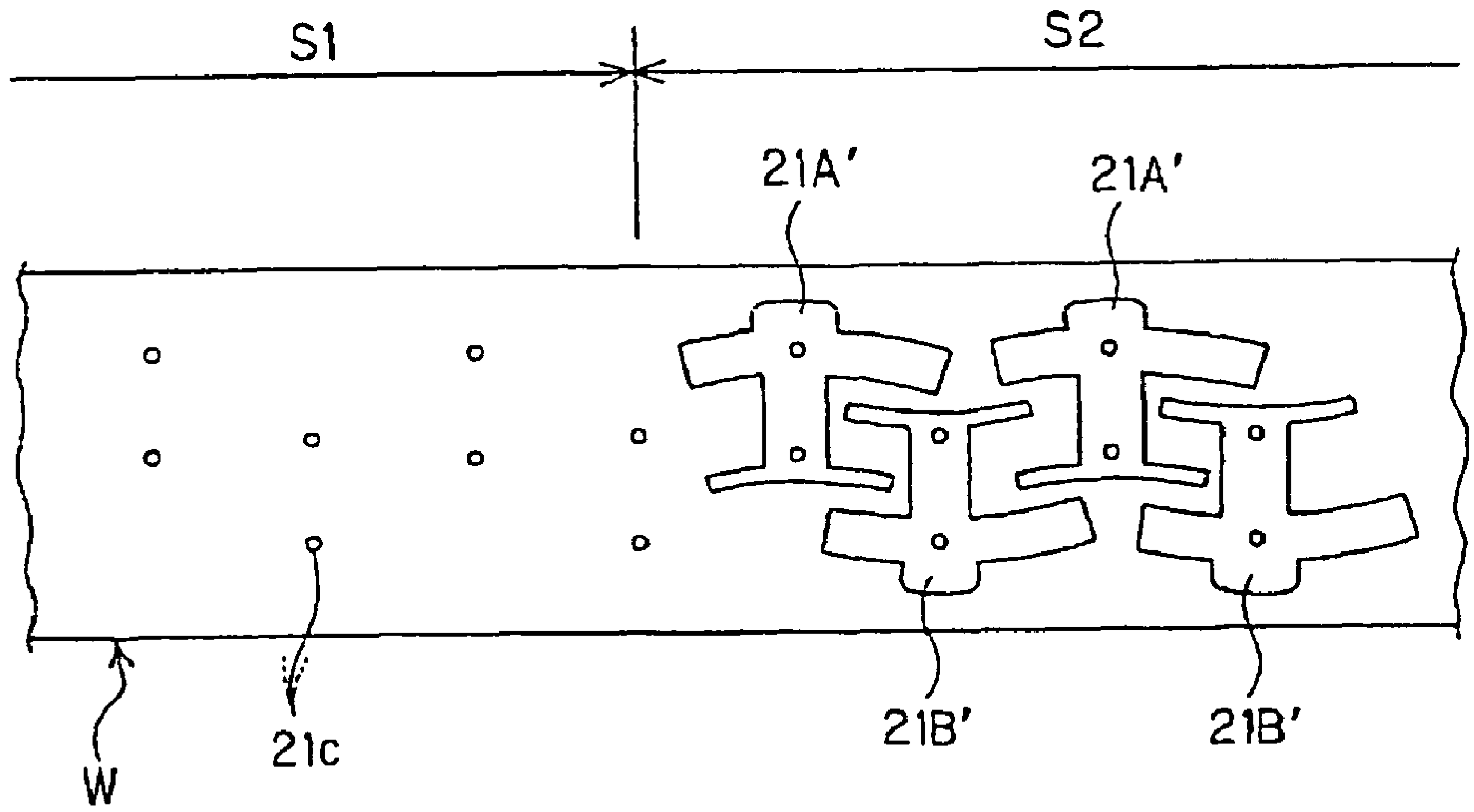


Fig. 50B

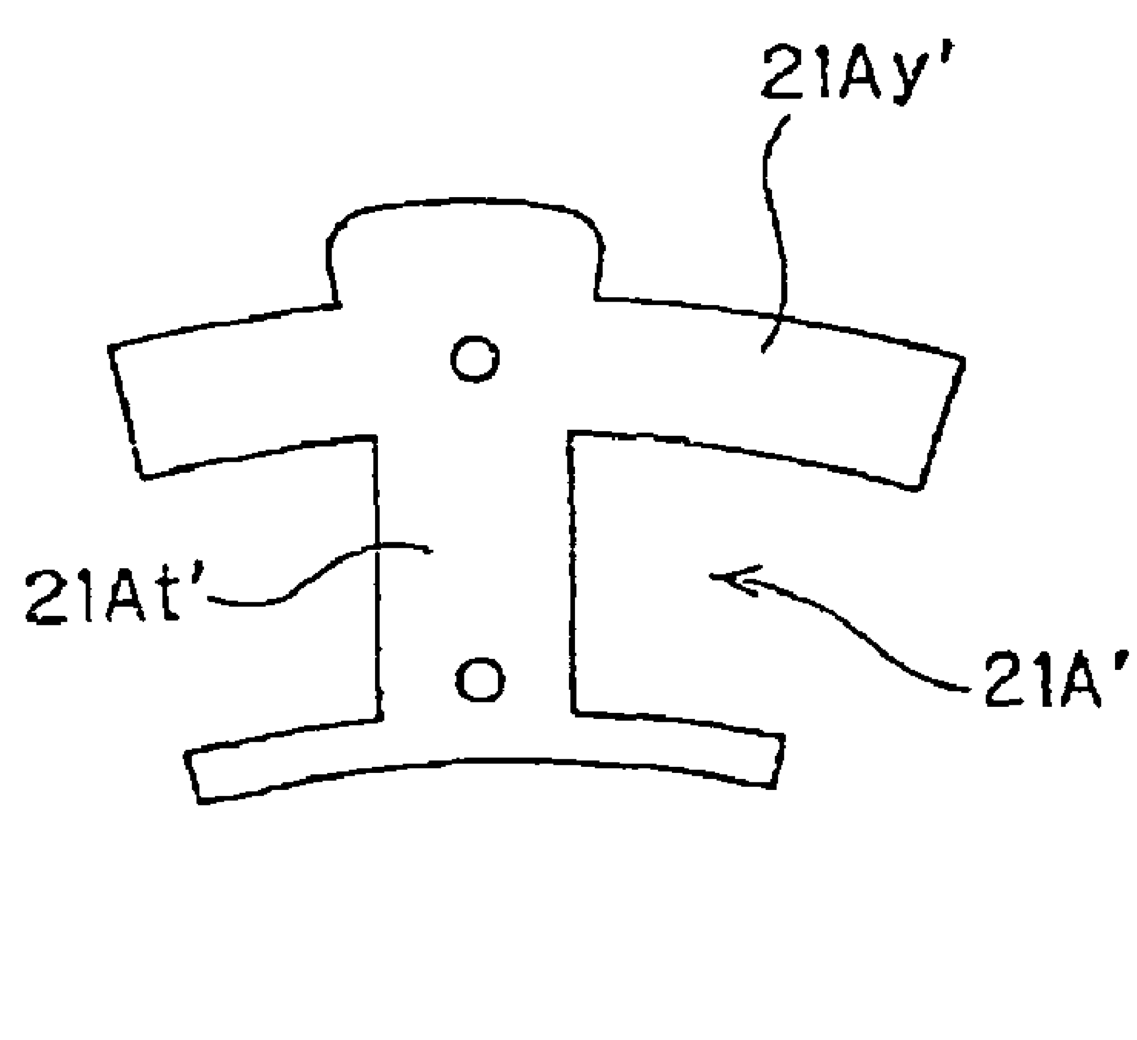


Fig. 50C

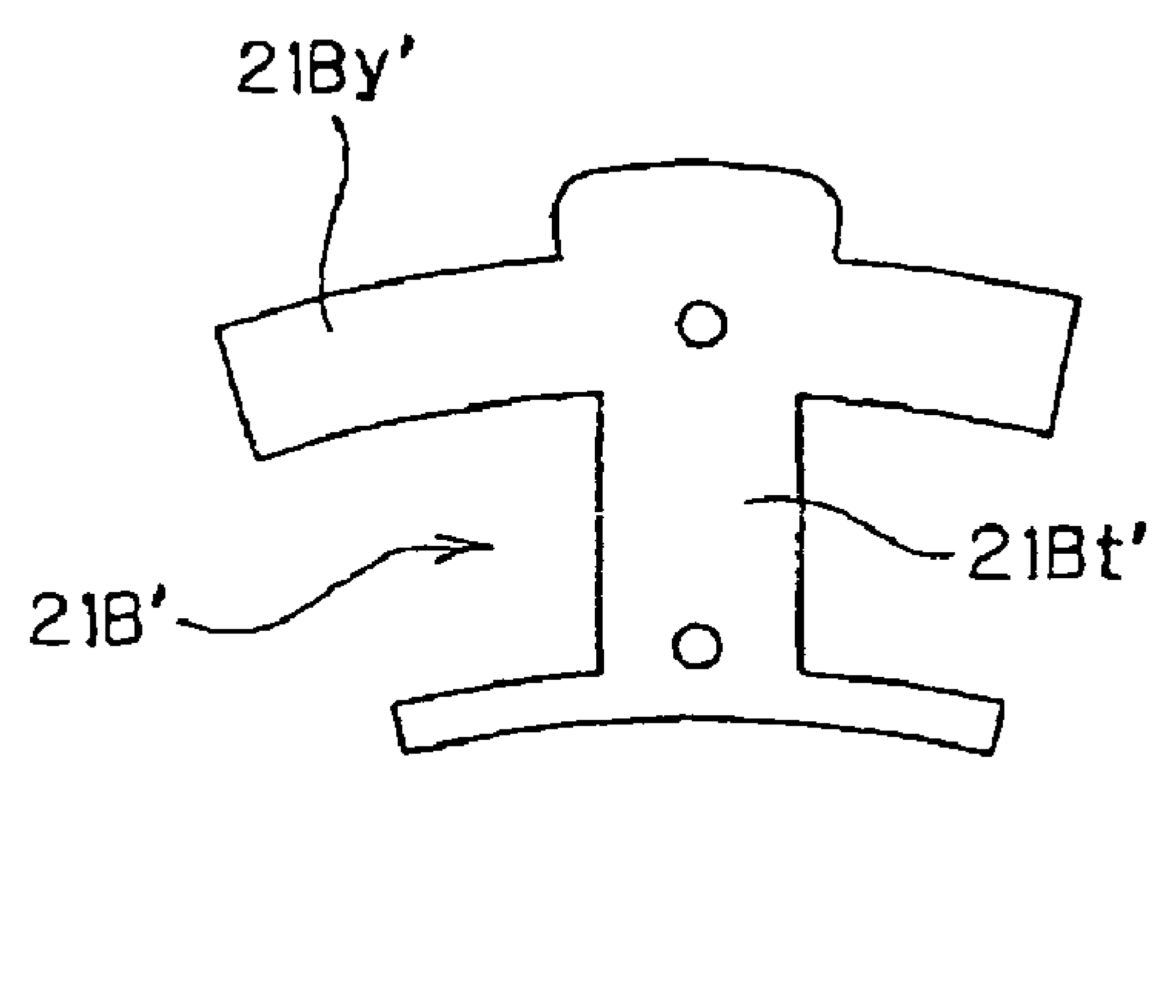


Fig. 51A

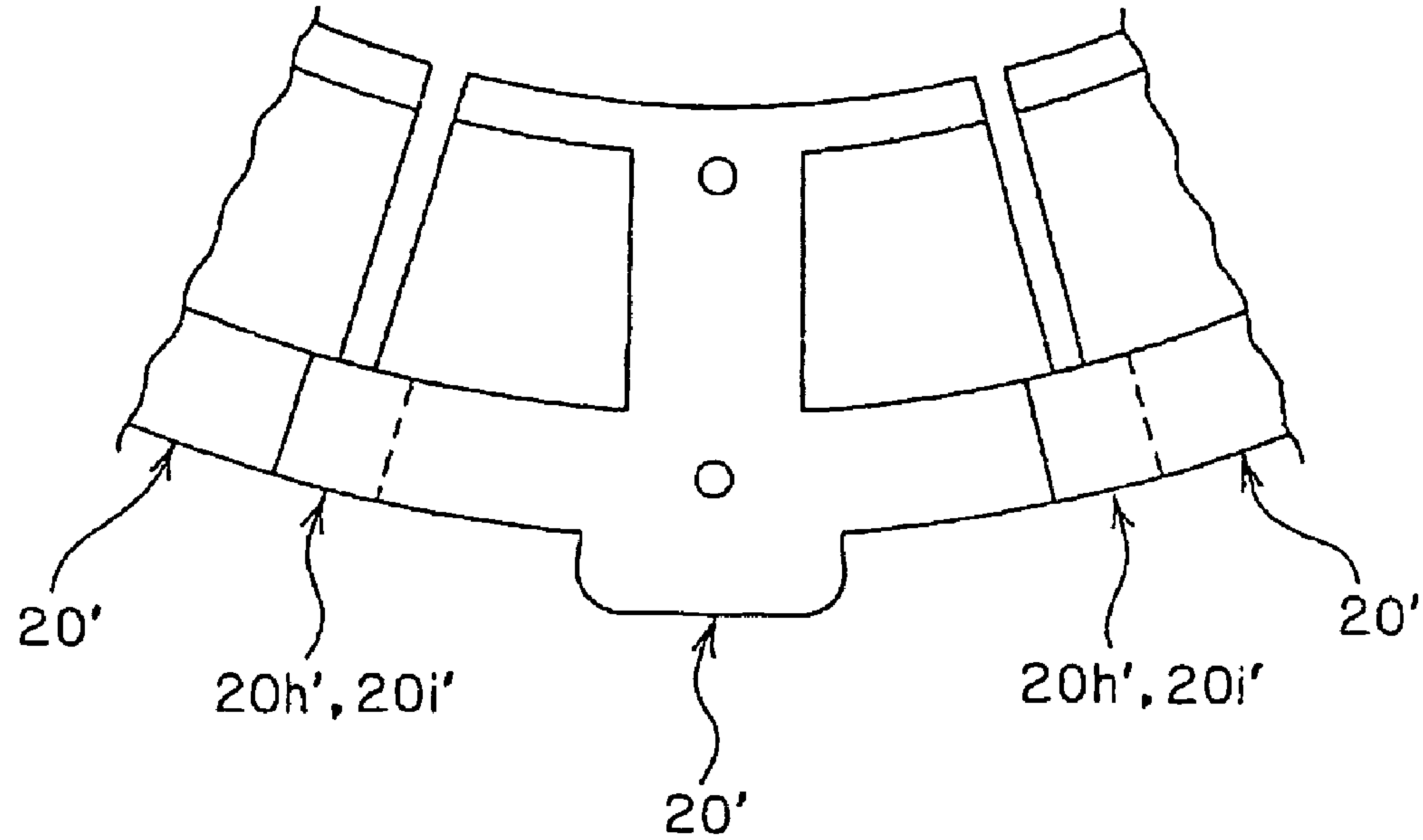


Fig. 51B

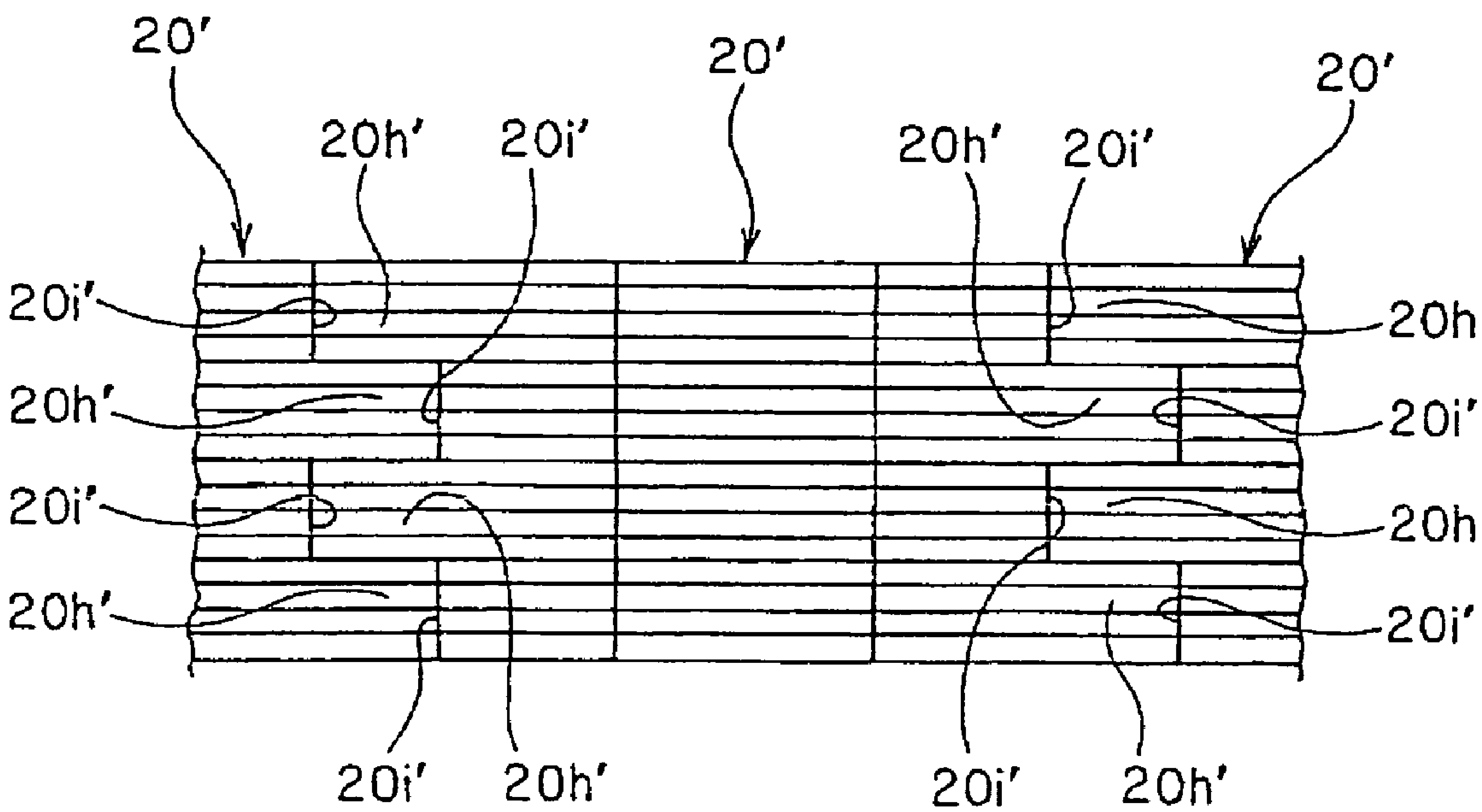


Fig. 52

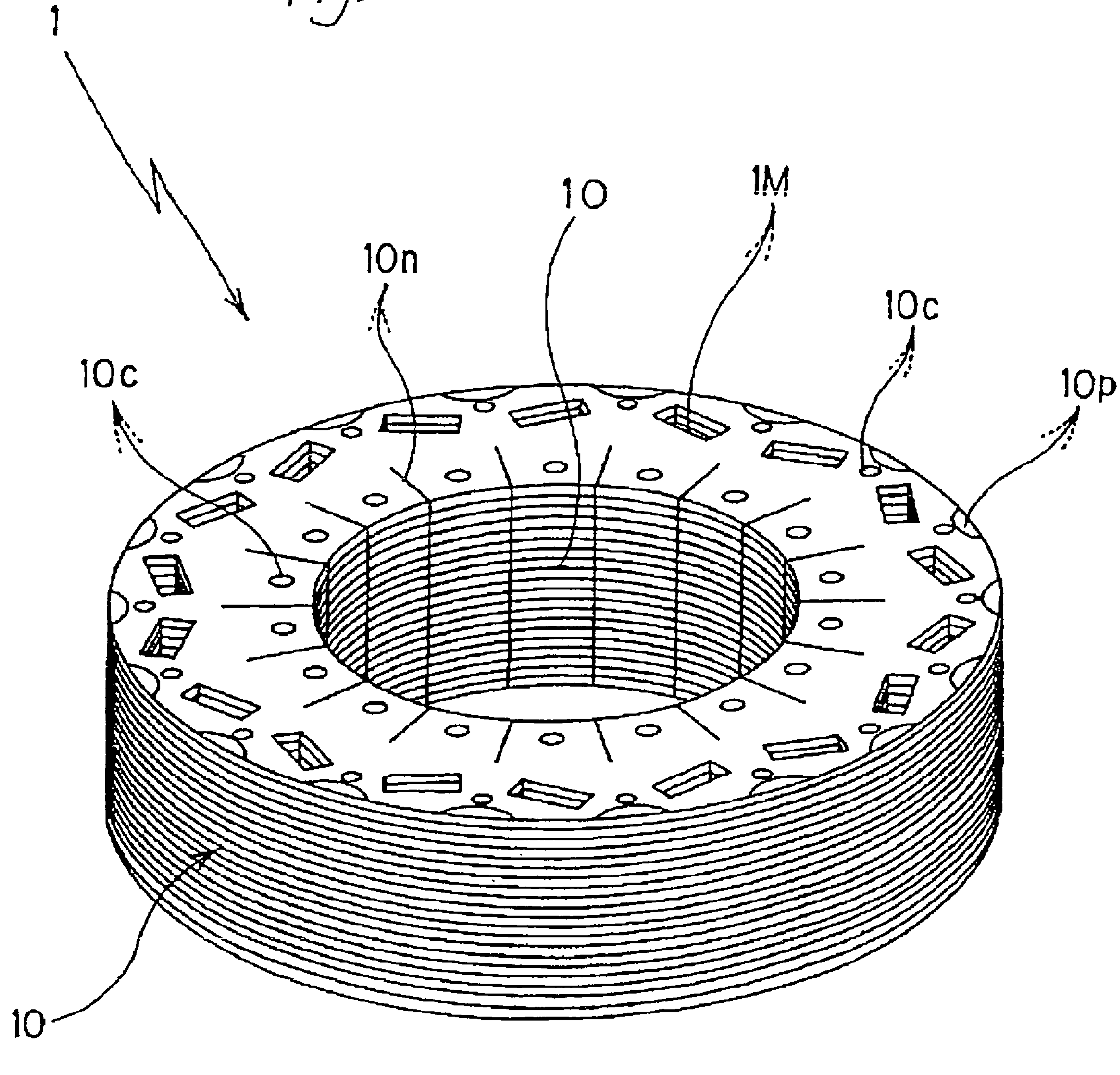


Fig. 53A

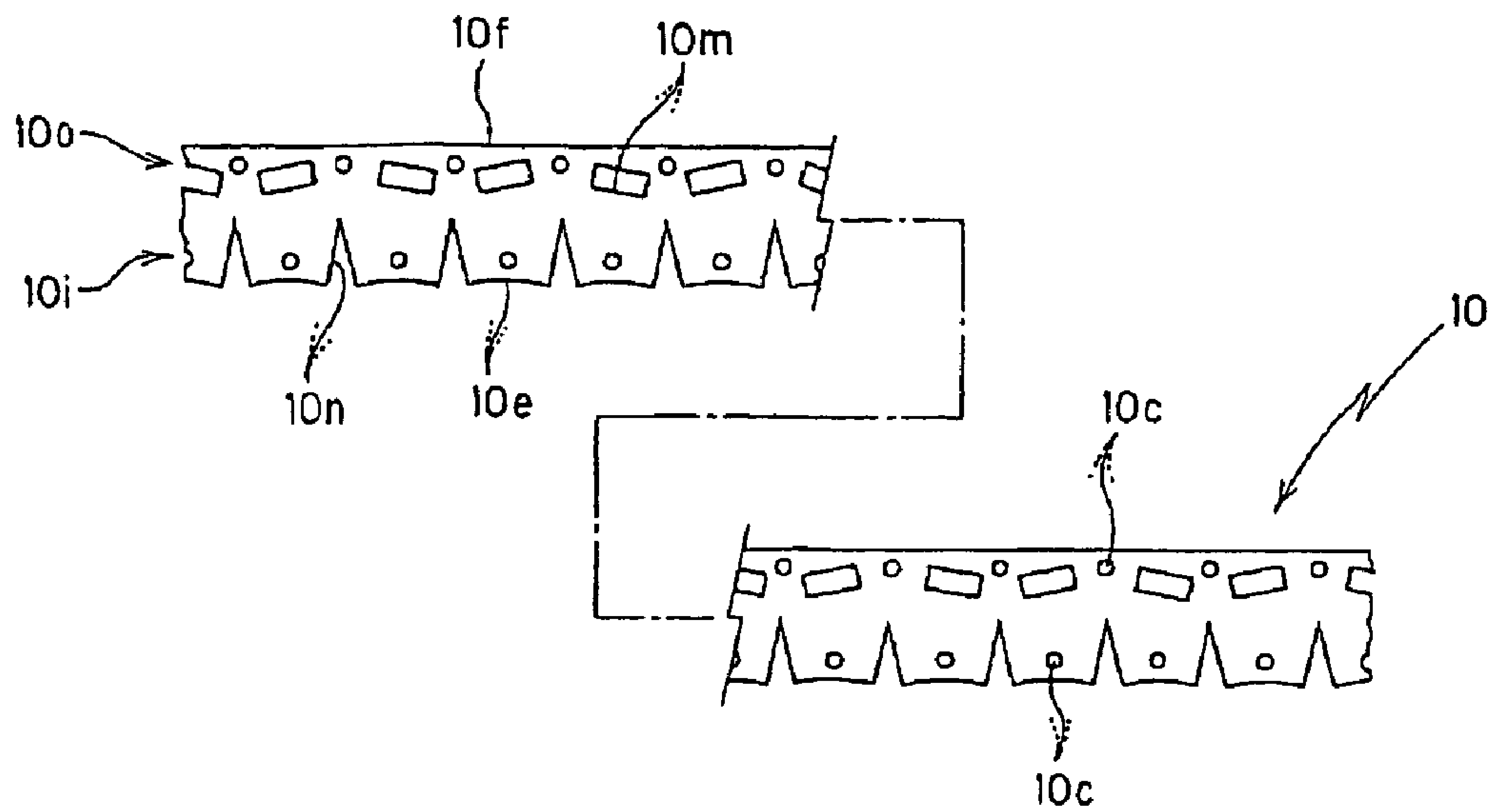


Fig. 53B

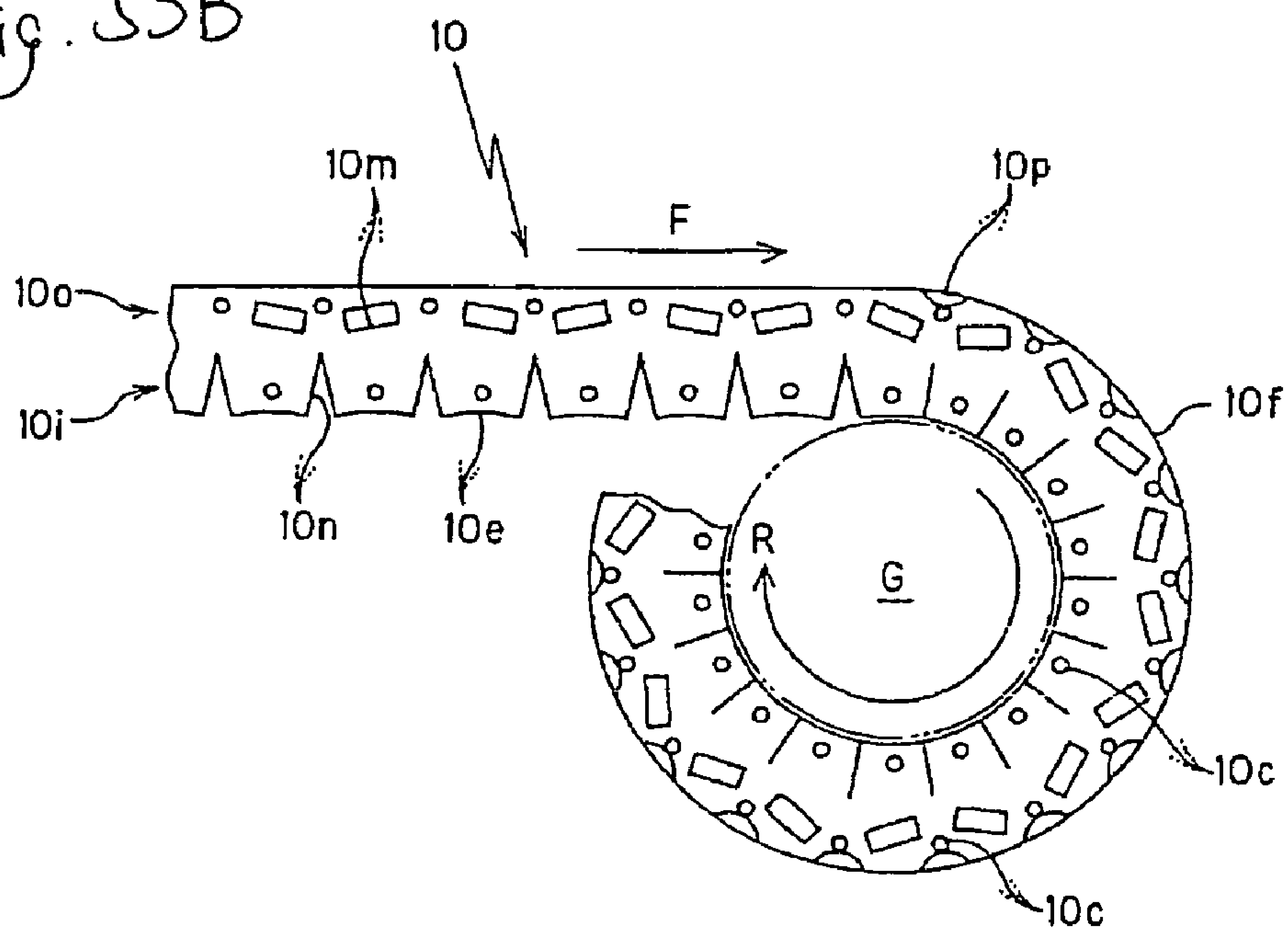


Fig. 54

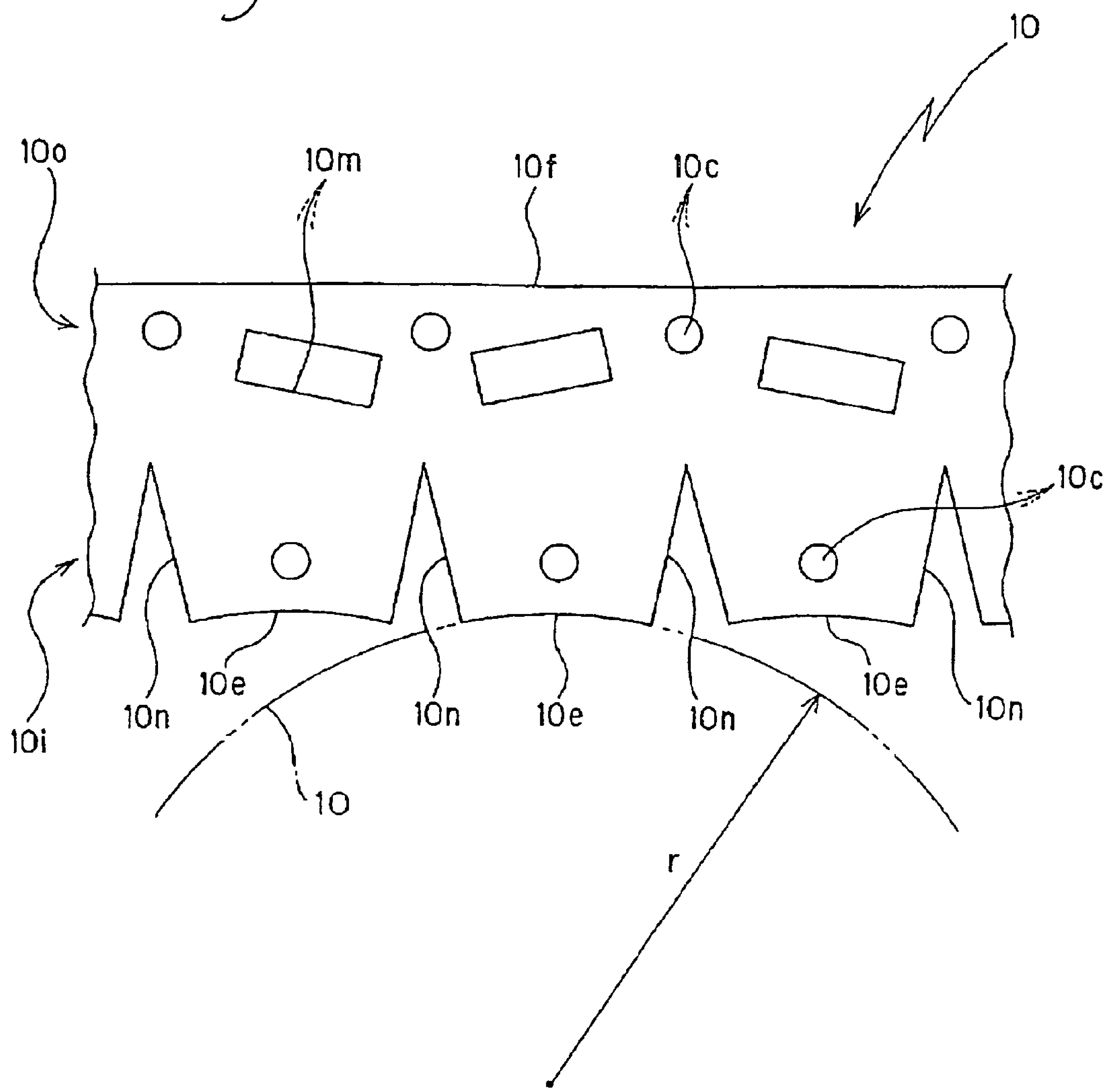


Fig. 55A

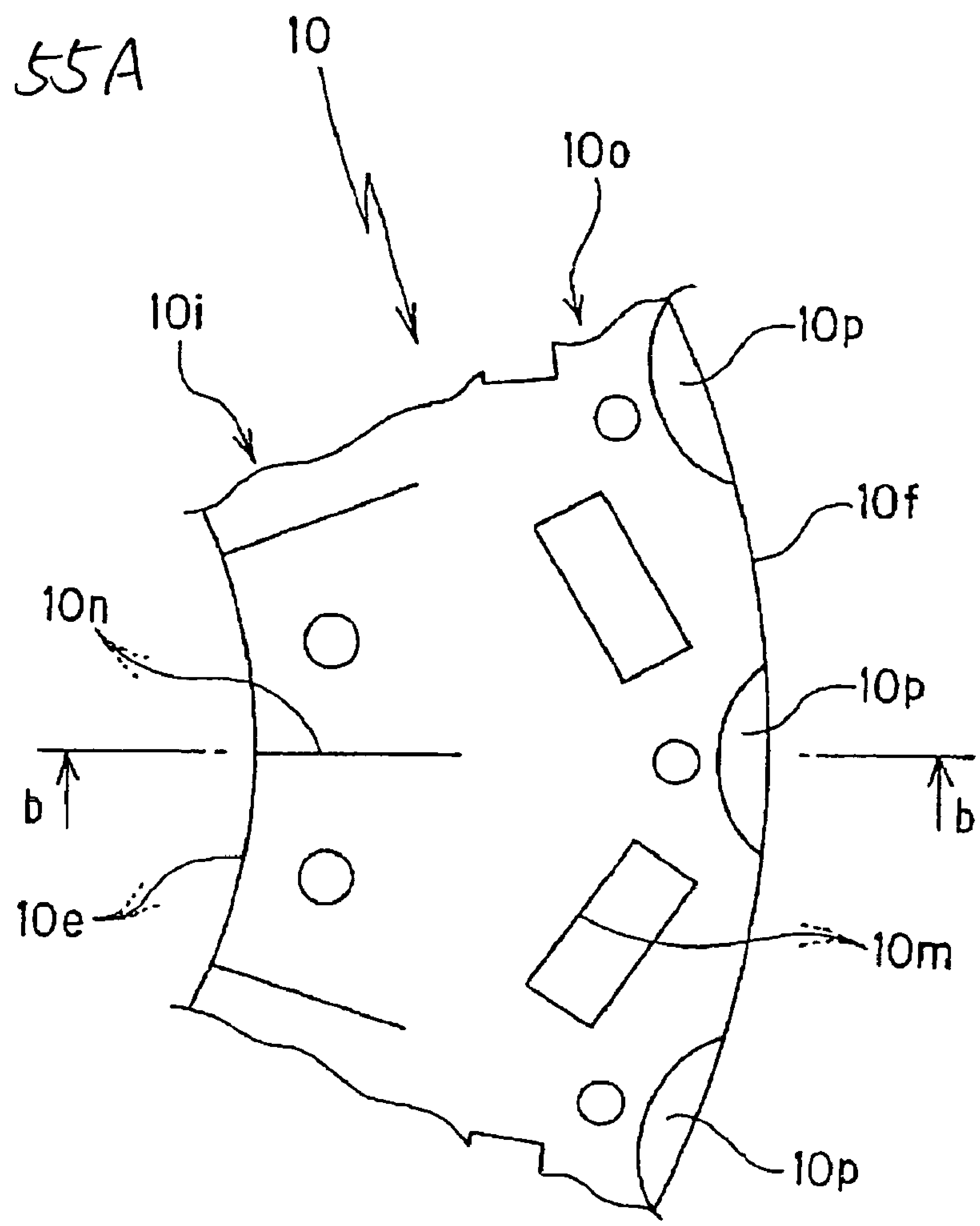


Fig. 55B

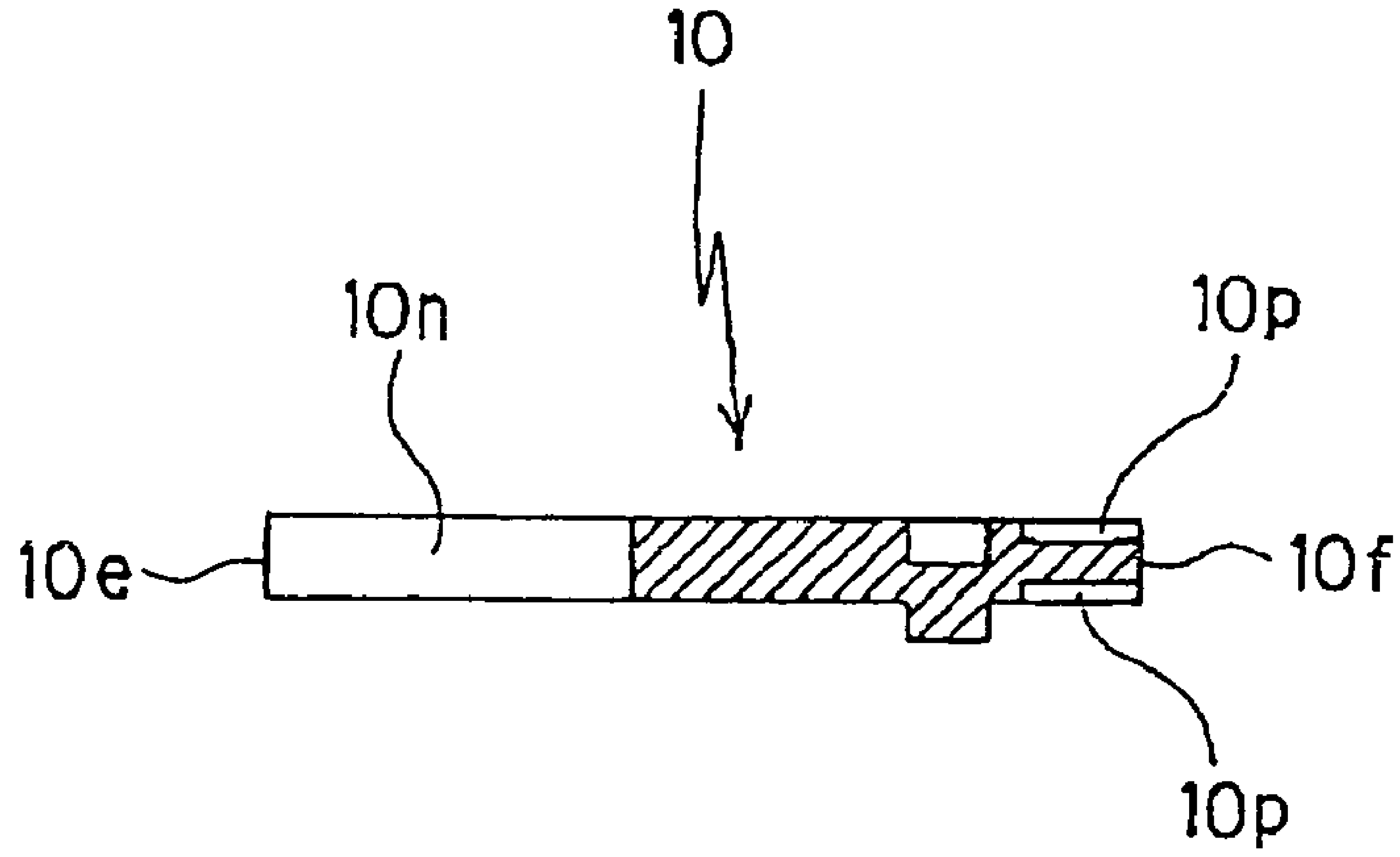


Fig. 56A

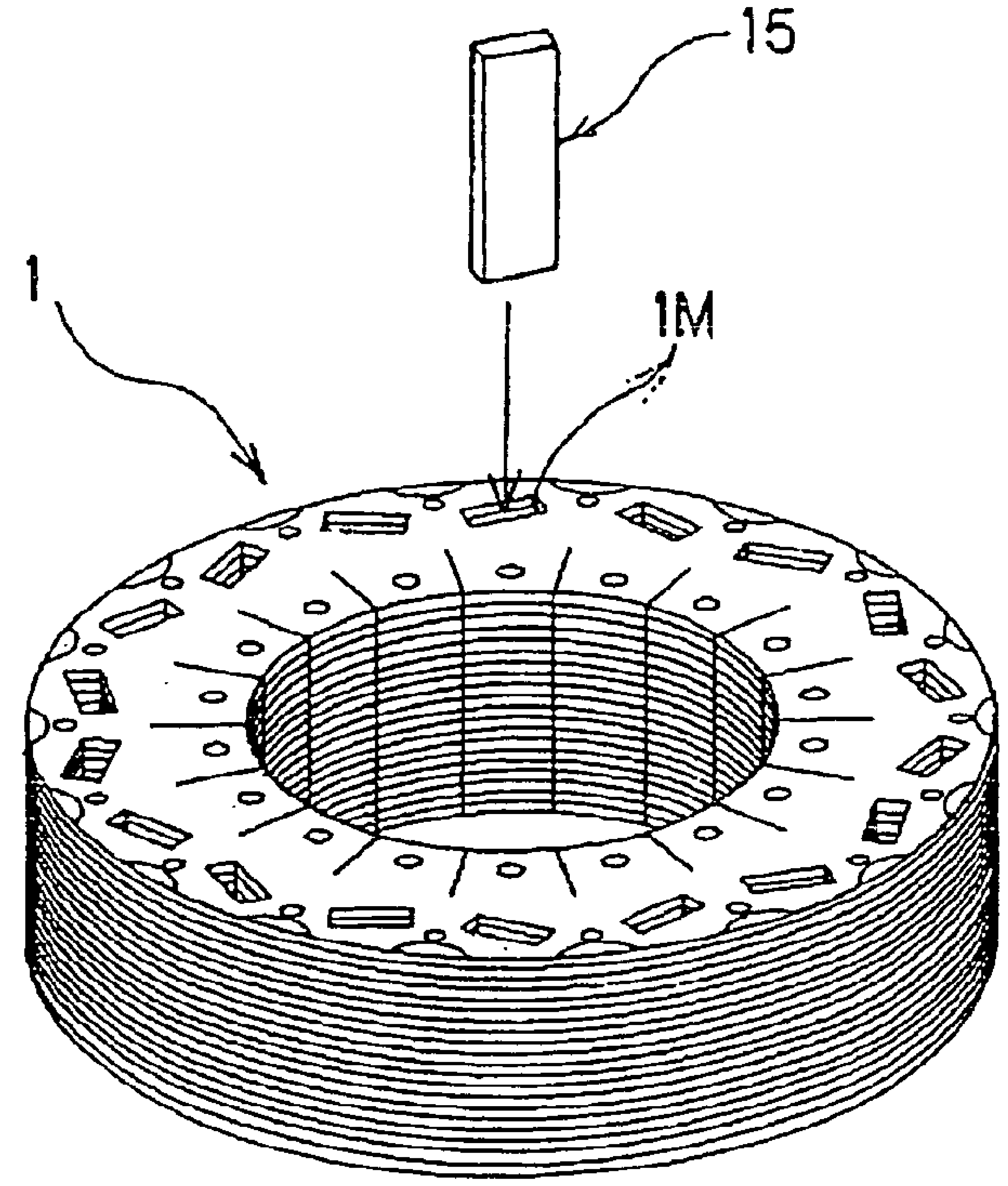


Fig. 56B

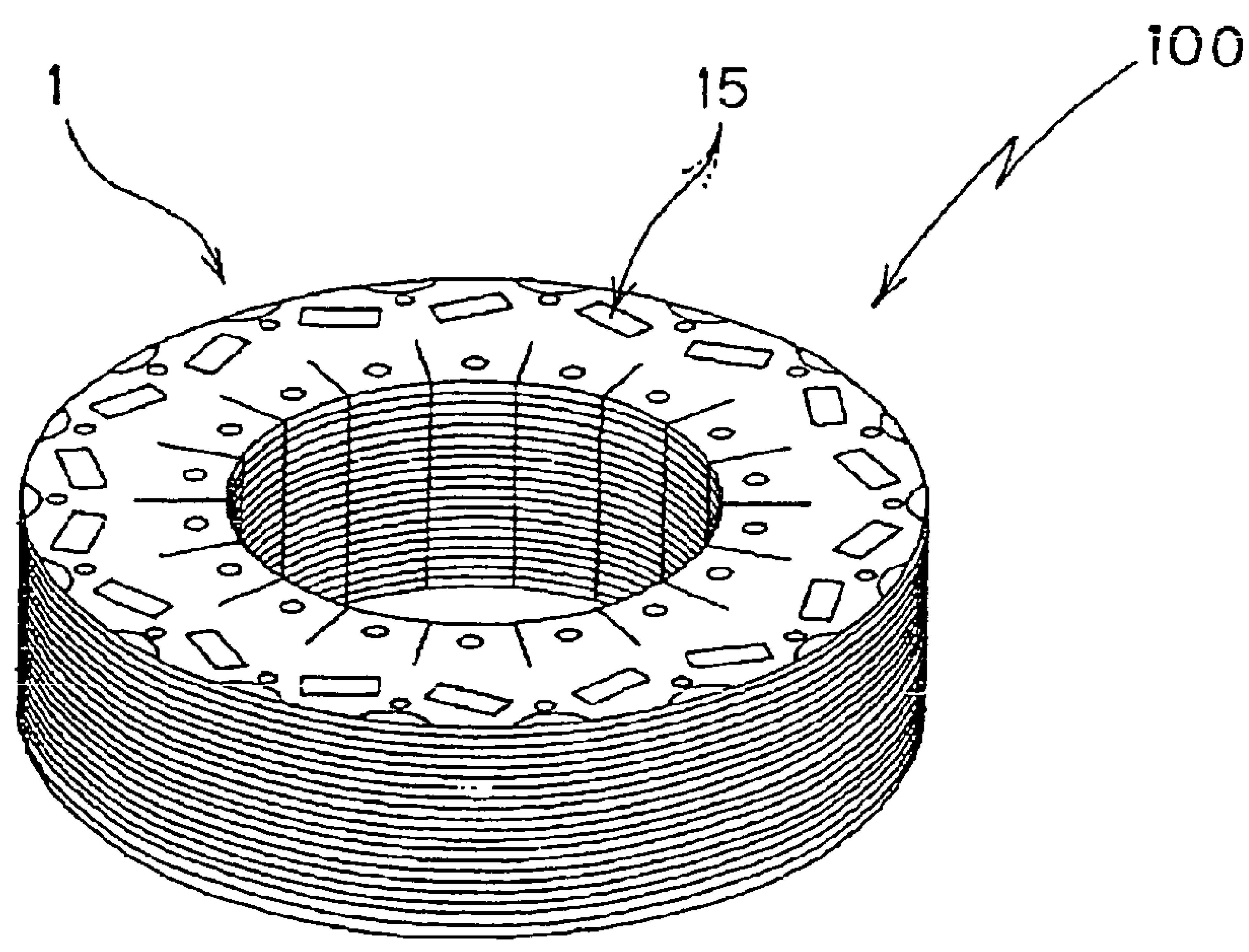


Fig. 57

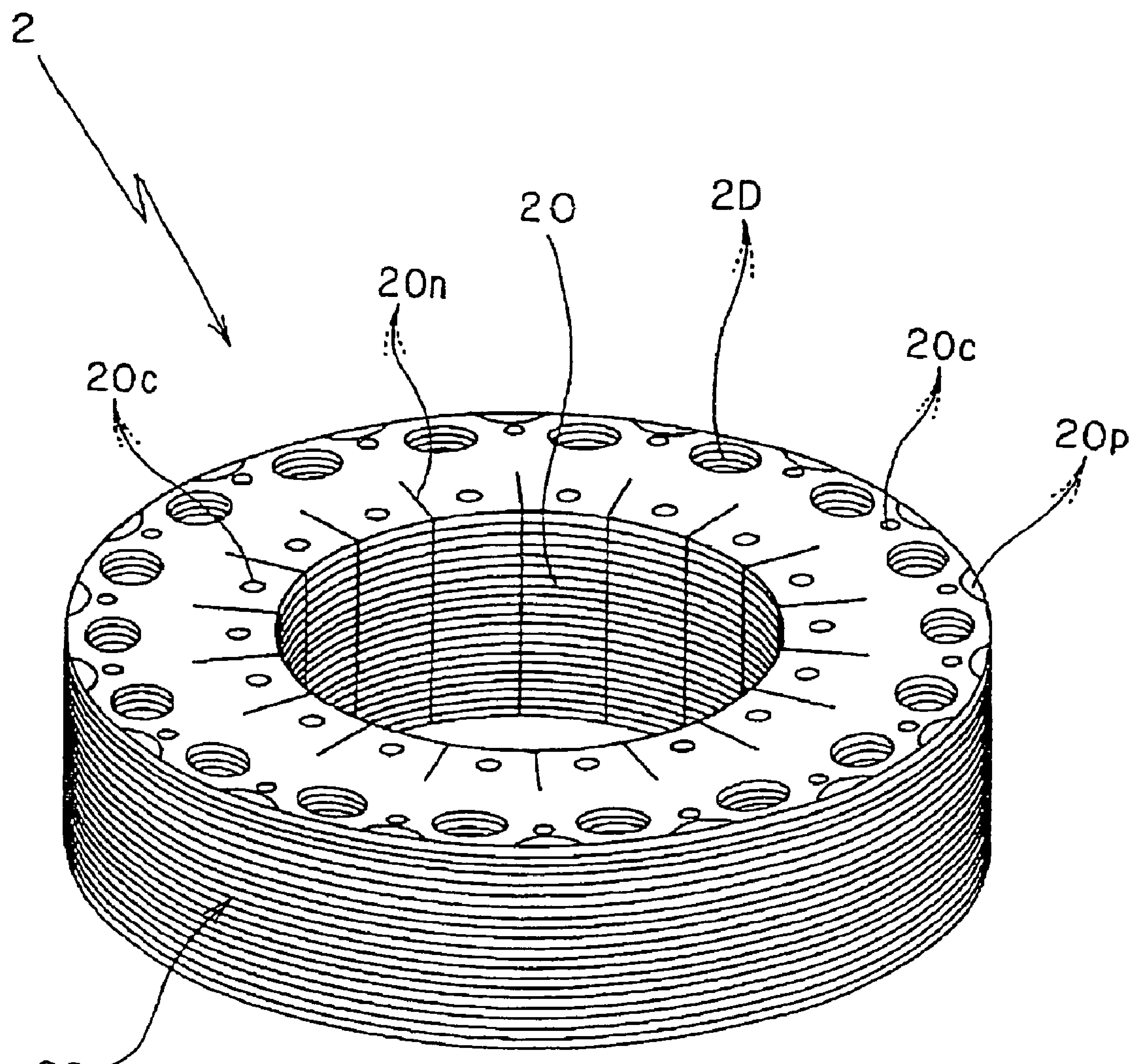


Fig. 58A

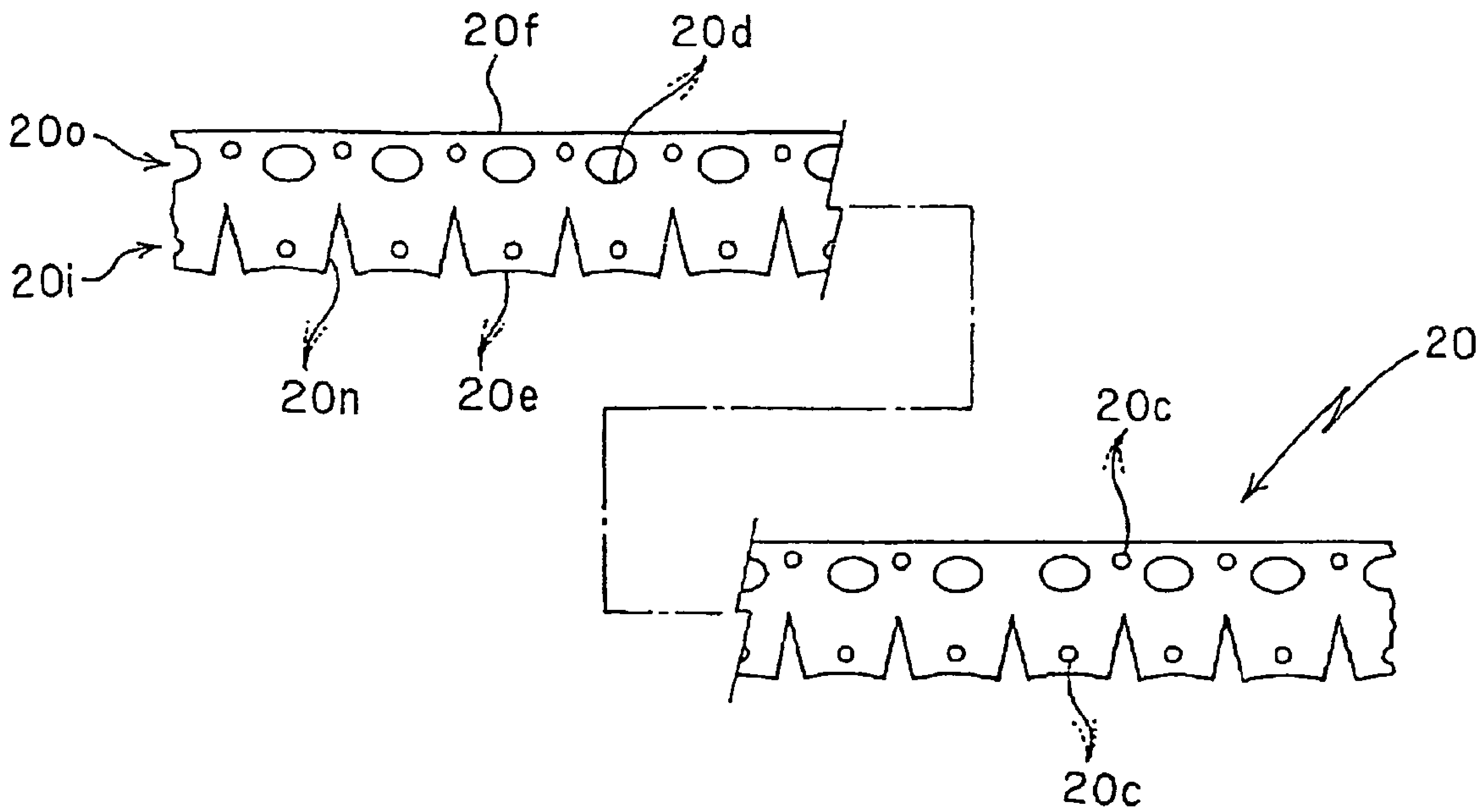


Fig. 58B

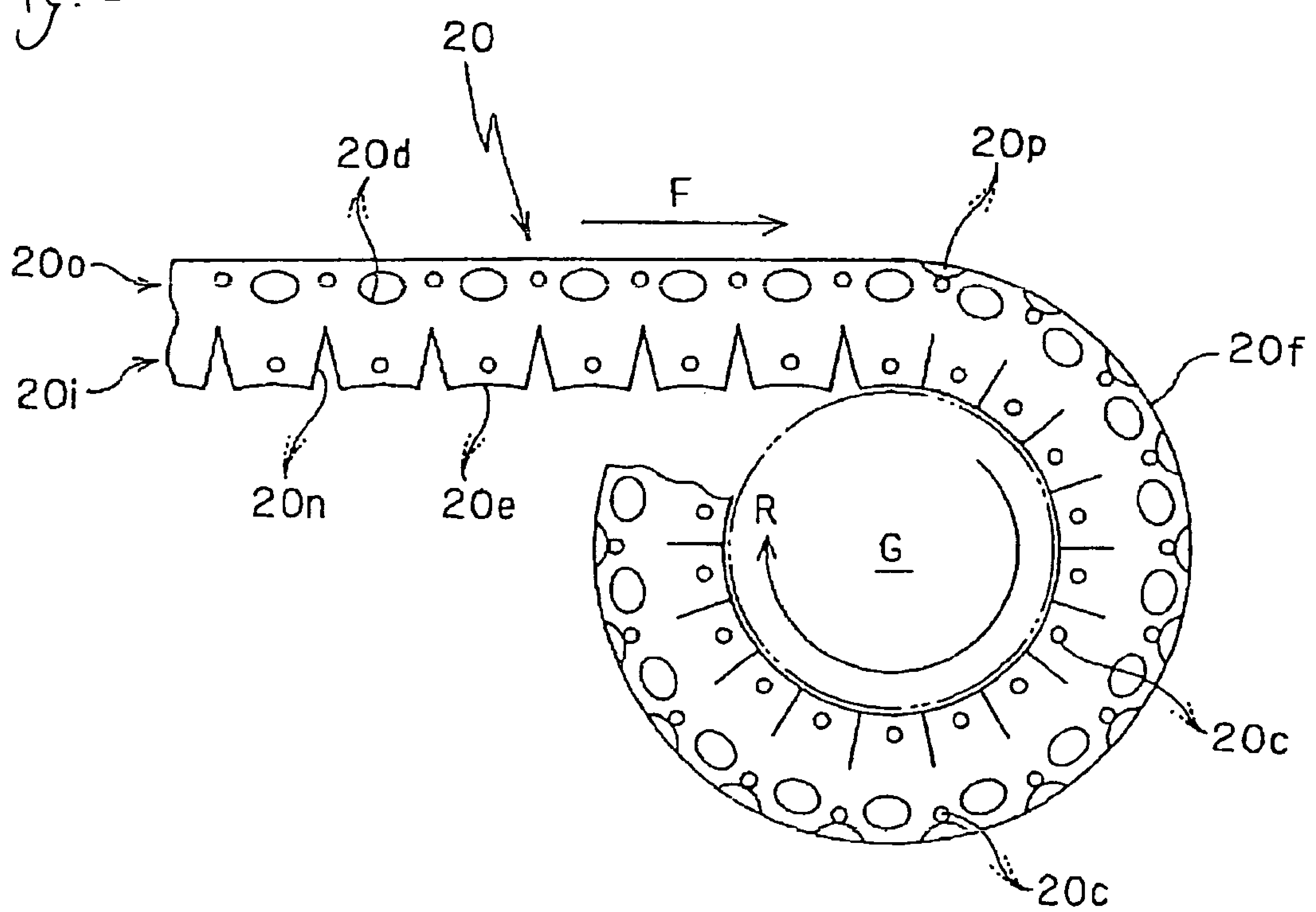


Fig. 59

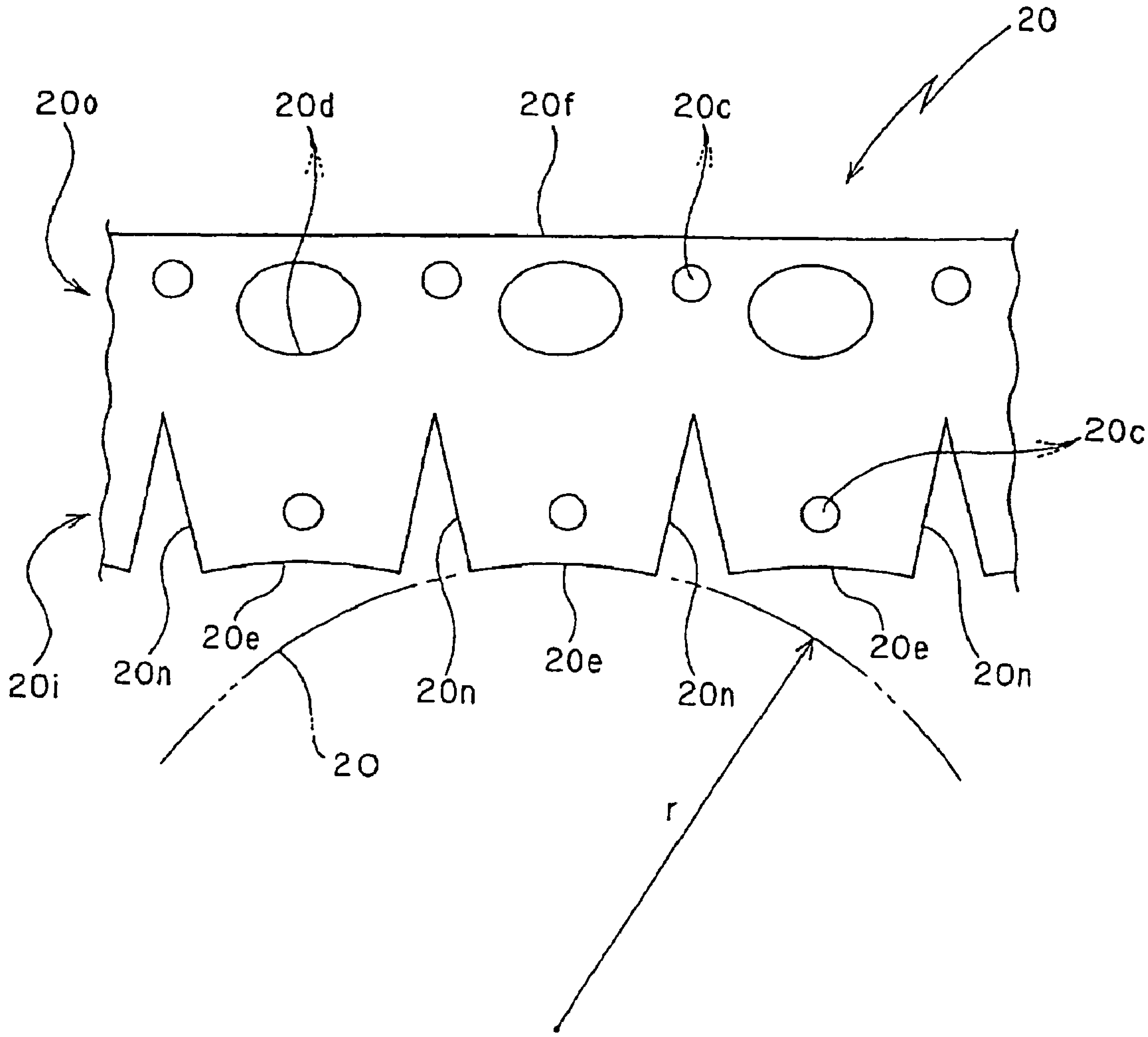


Fig. 60A

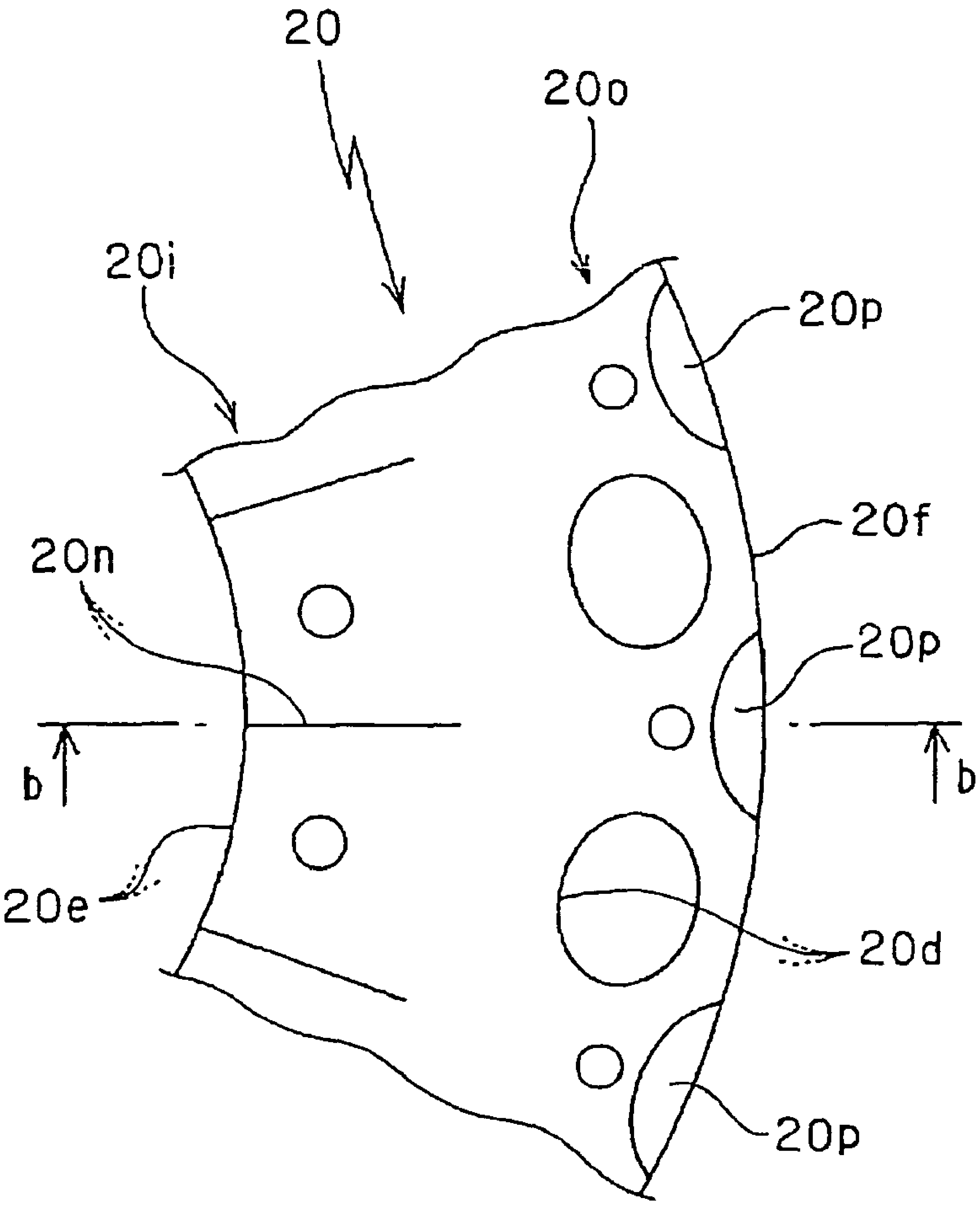


Fig. 60B

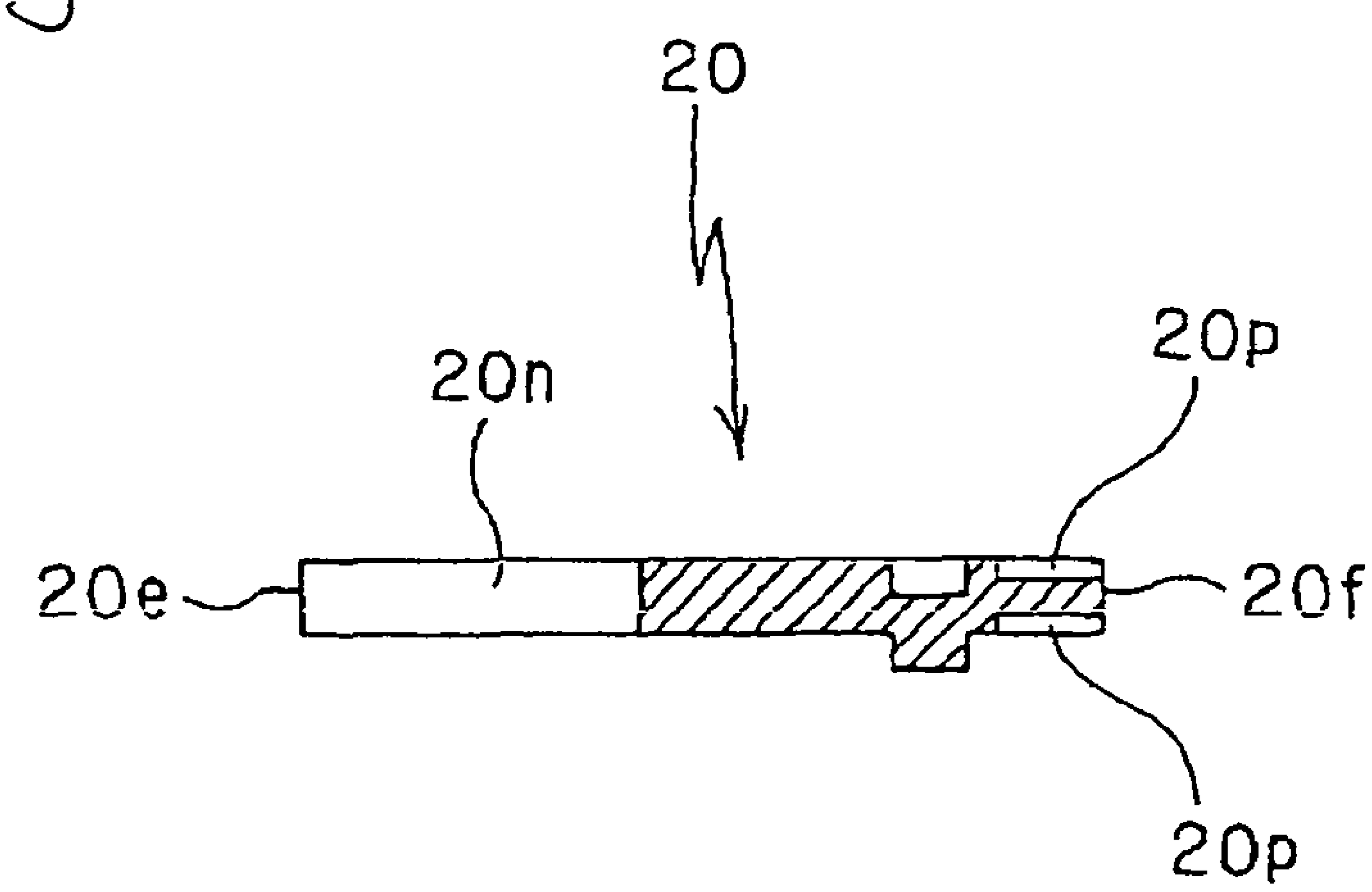


Fig. 61A

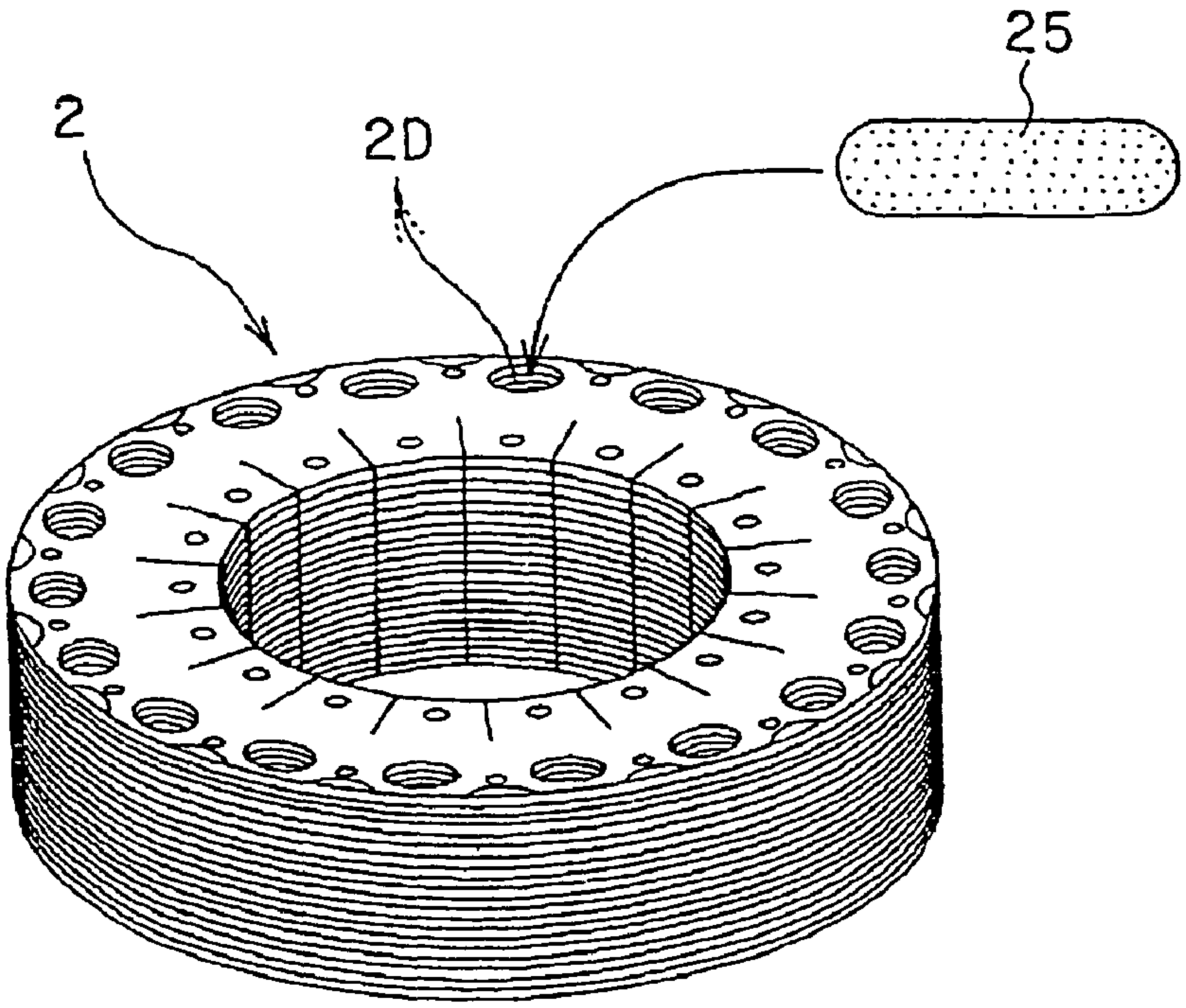


Fig. 61B

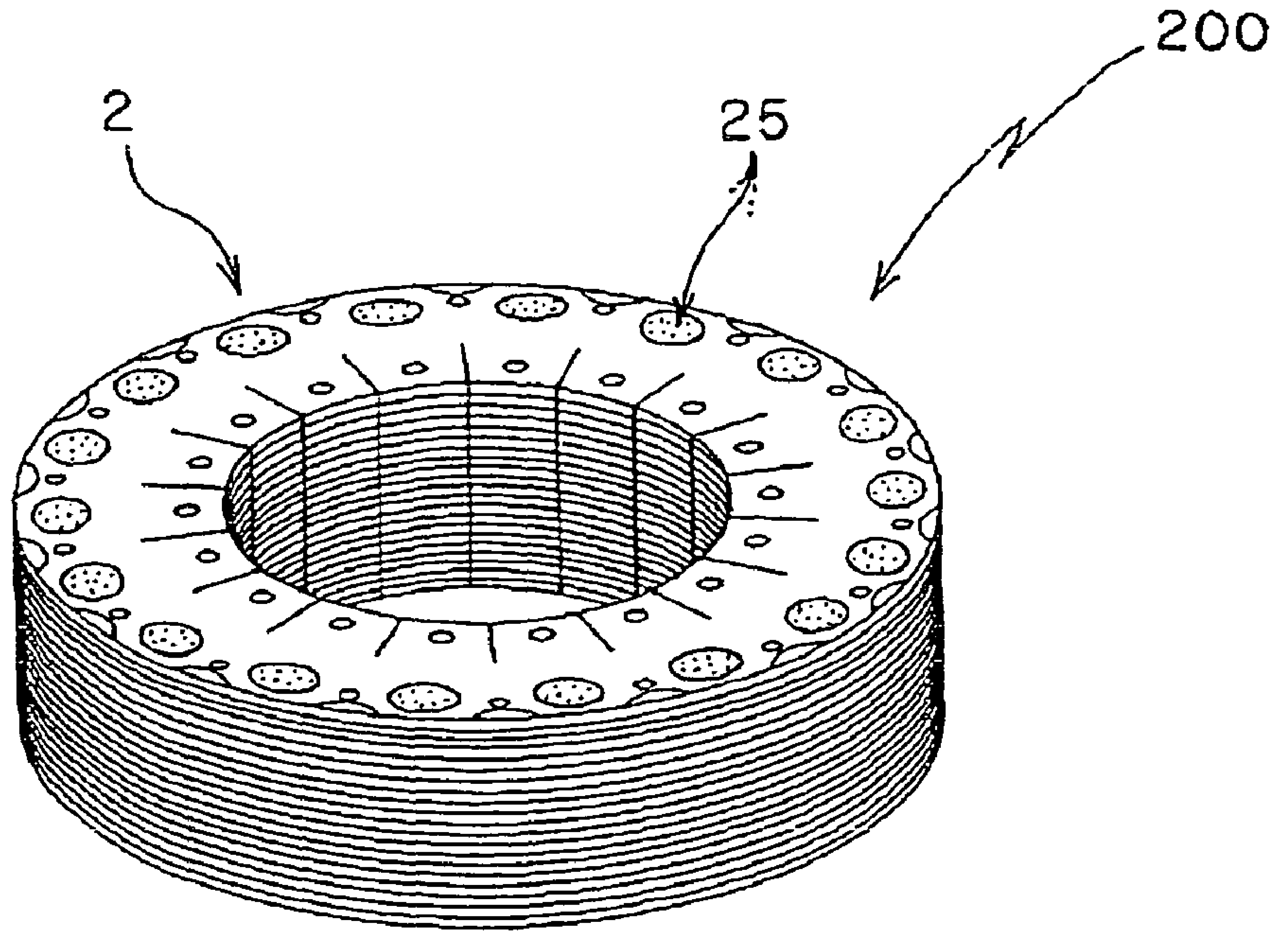


Fig. 62A

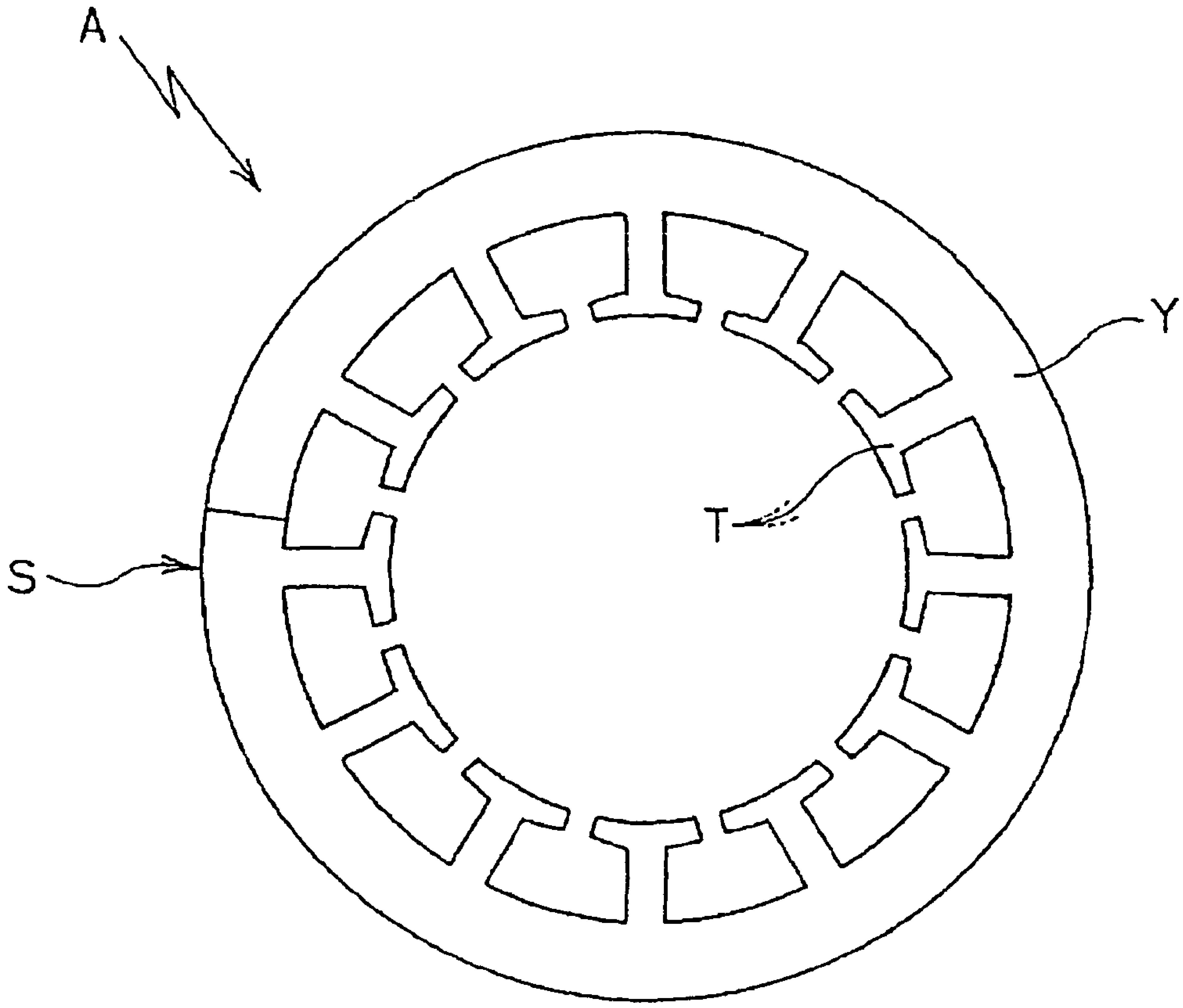


Fig. 62B

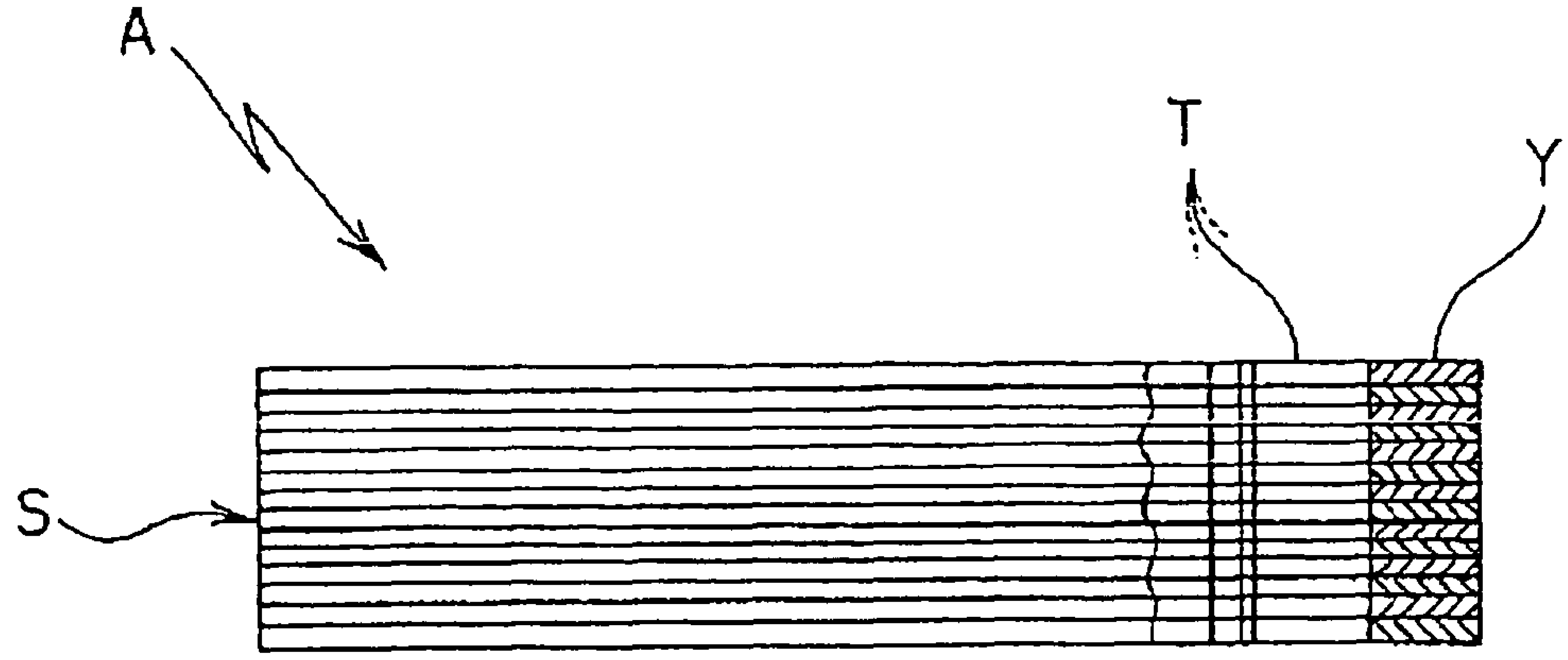


Fig. 63

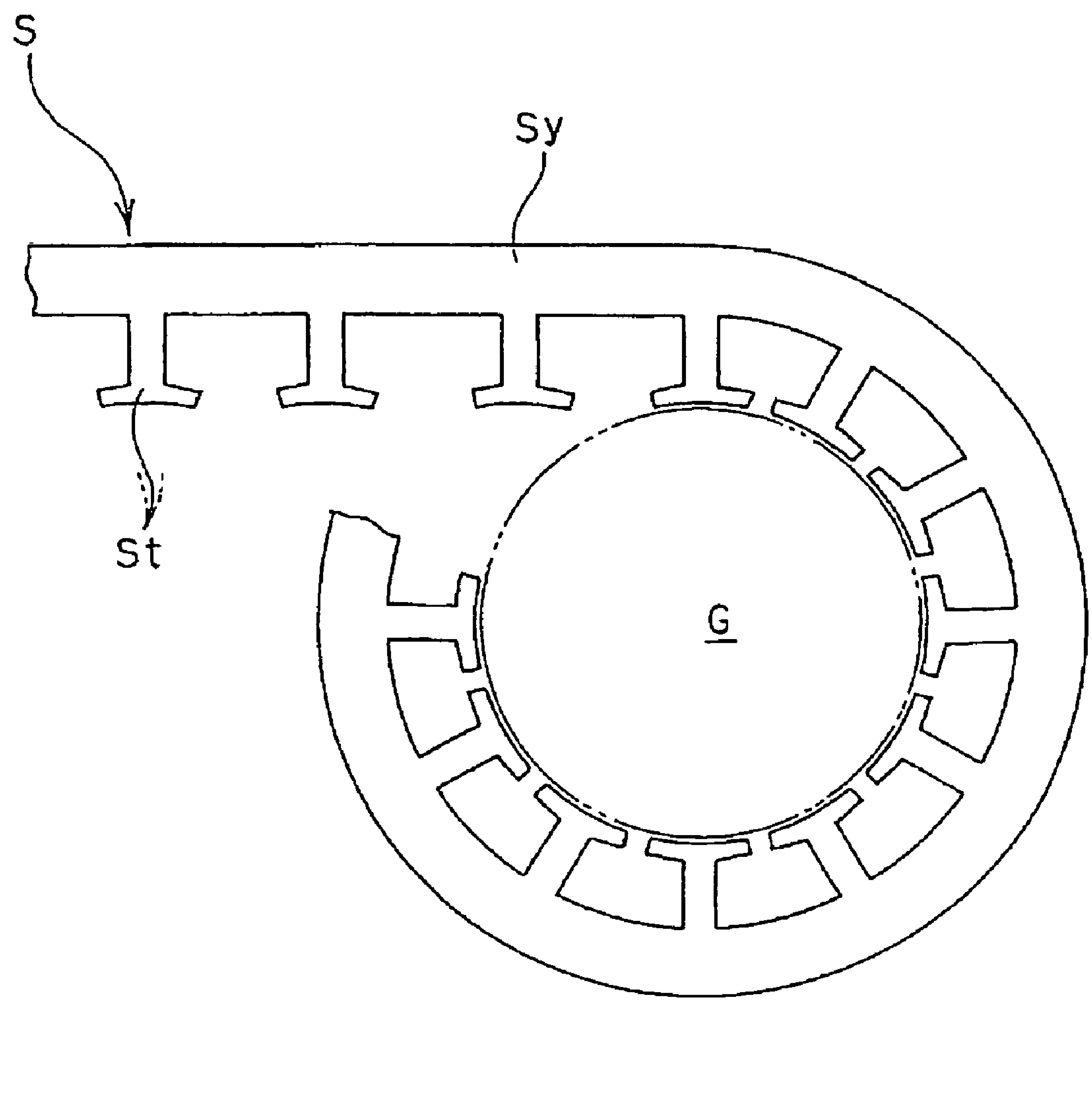


Fig. 64A

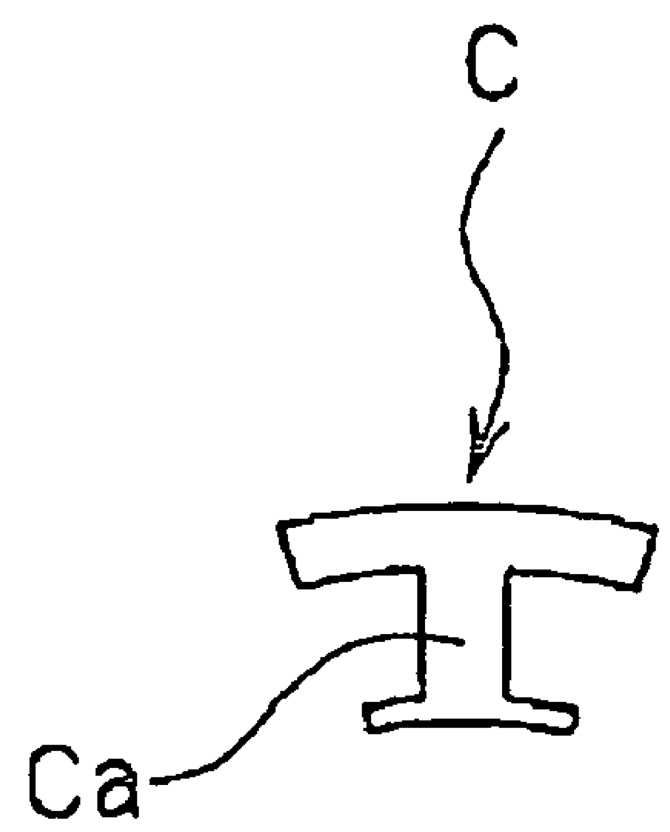


Fig. 64B

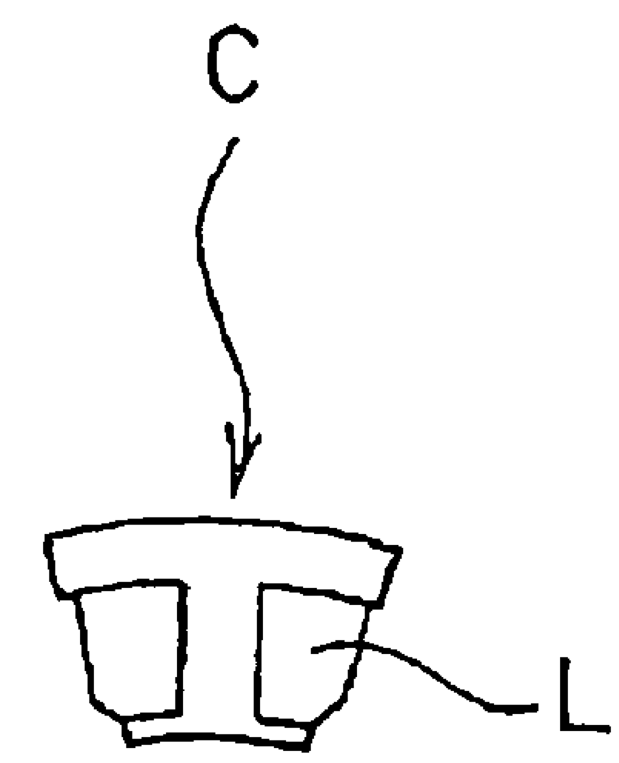


Fig. 64C

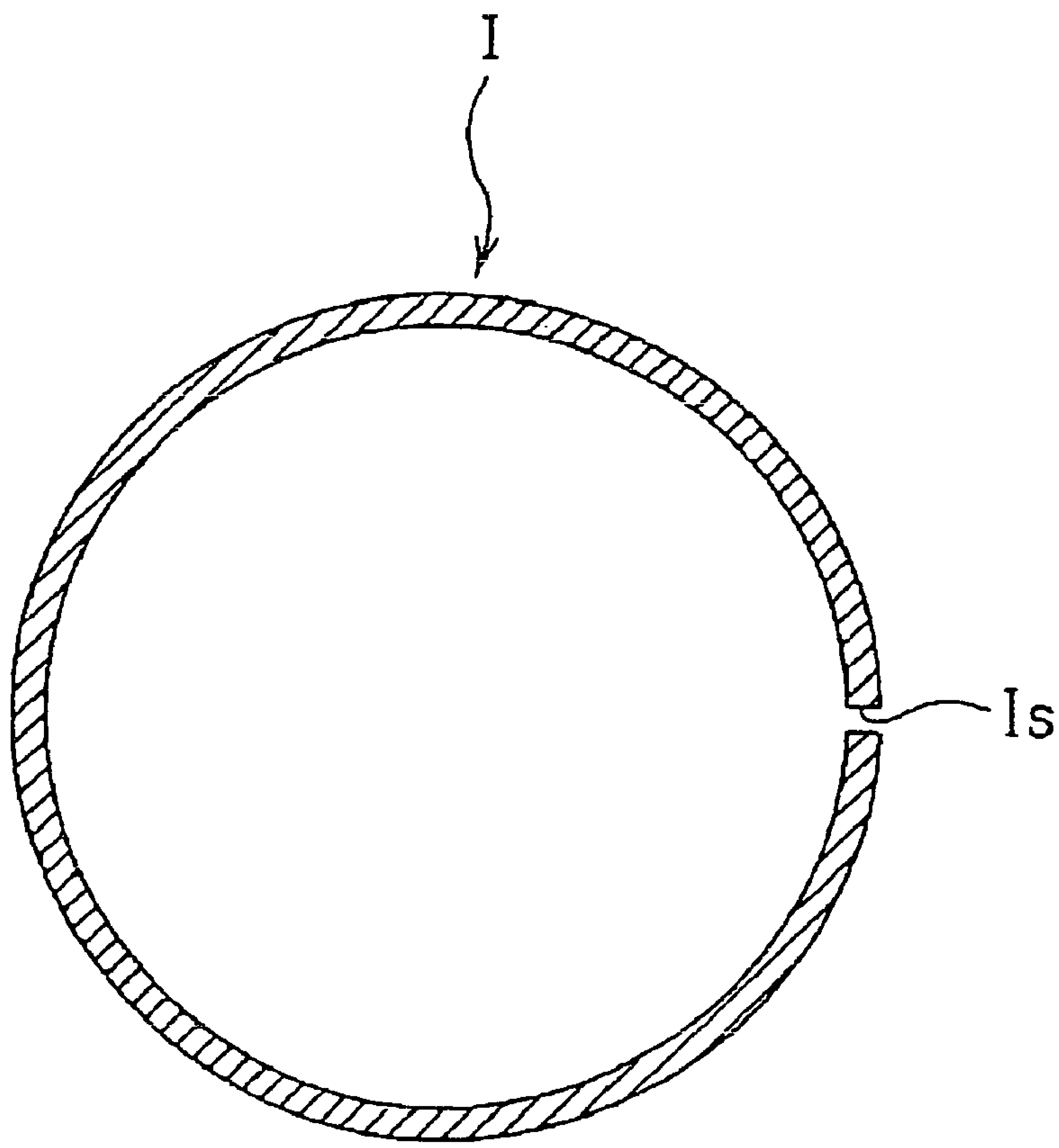


Fig. 65A

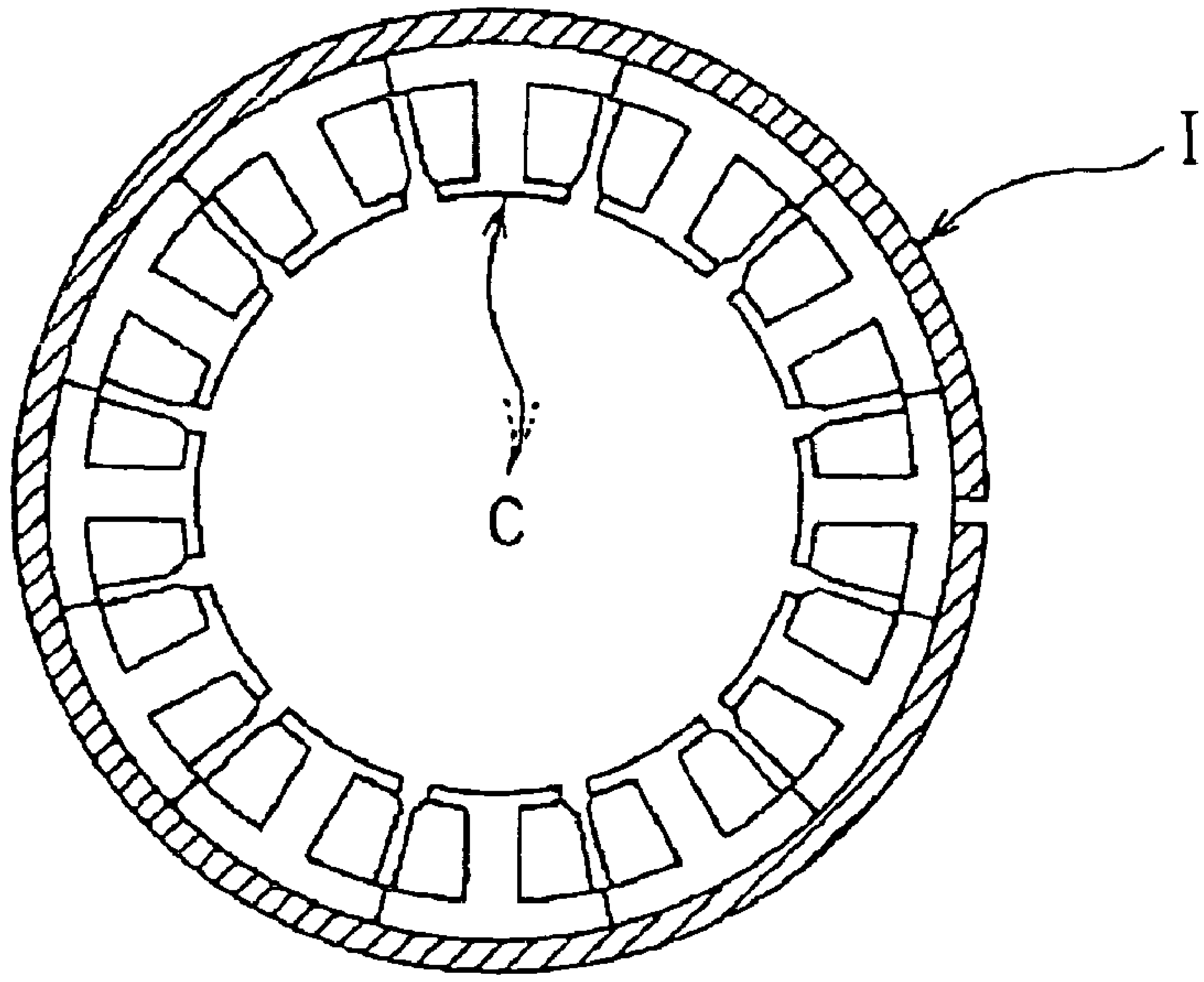


Fig. 65B

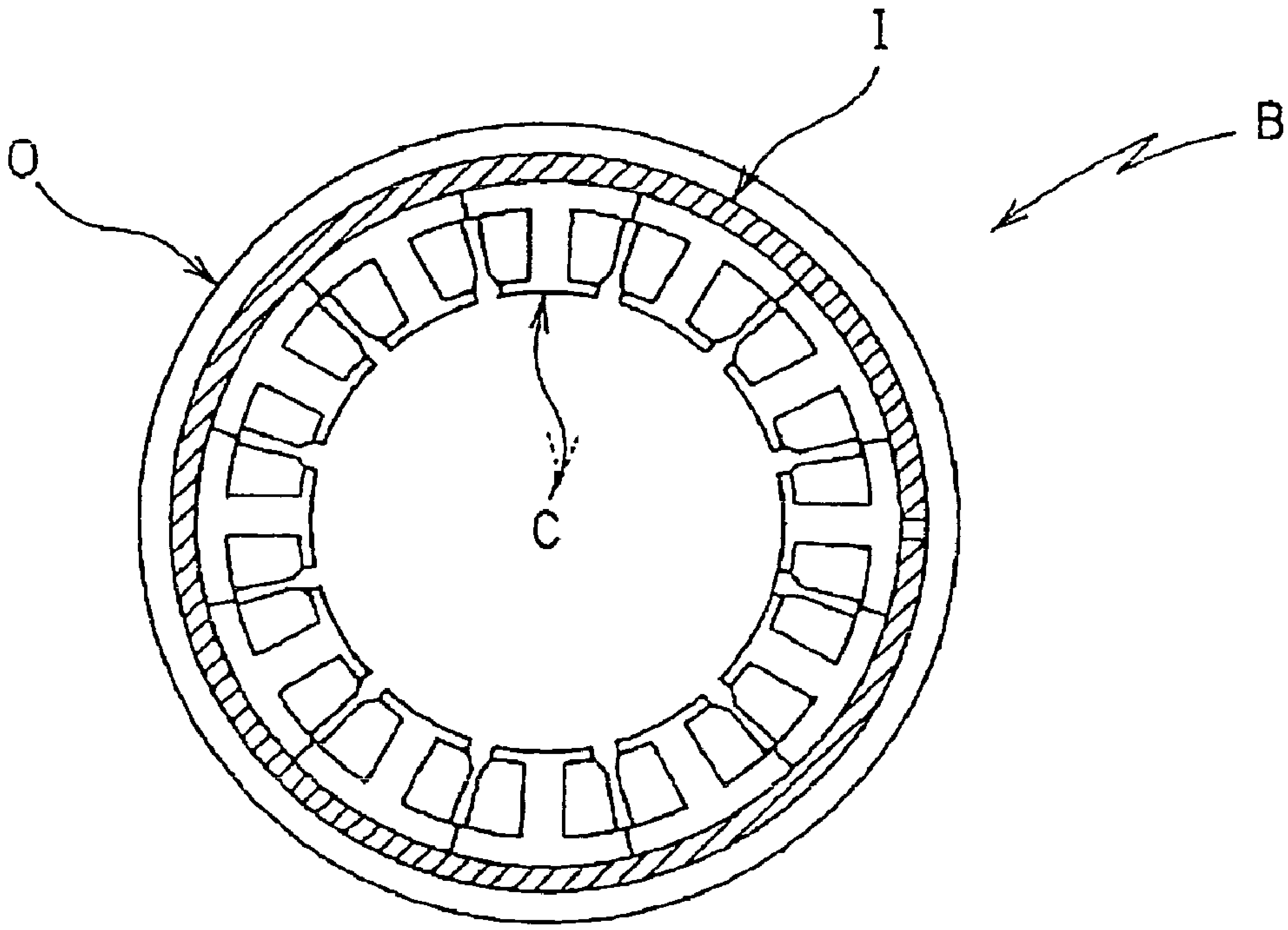


Fig. 66A

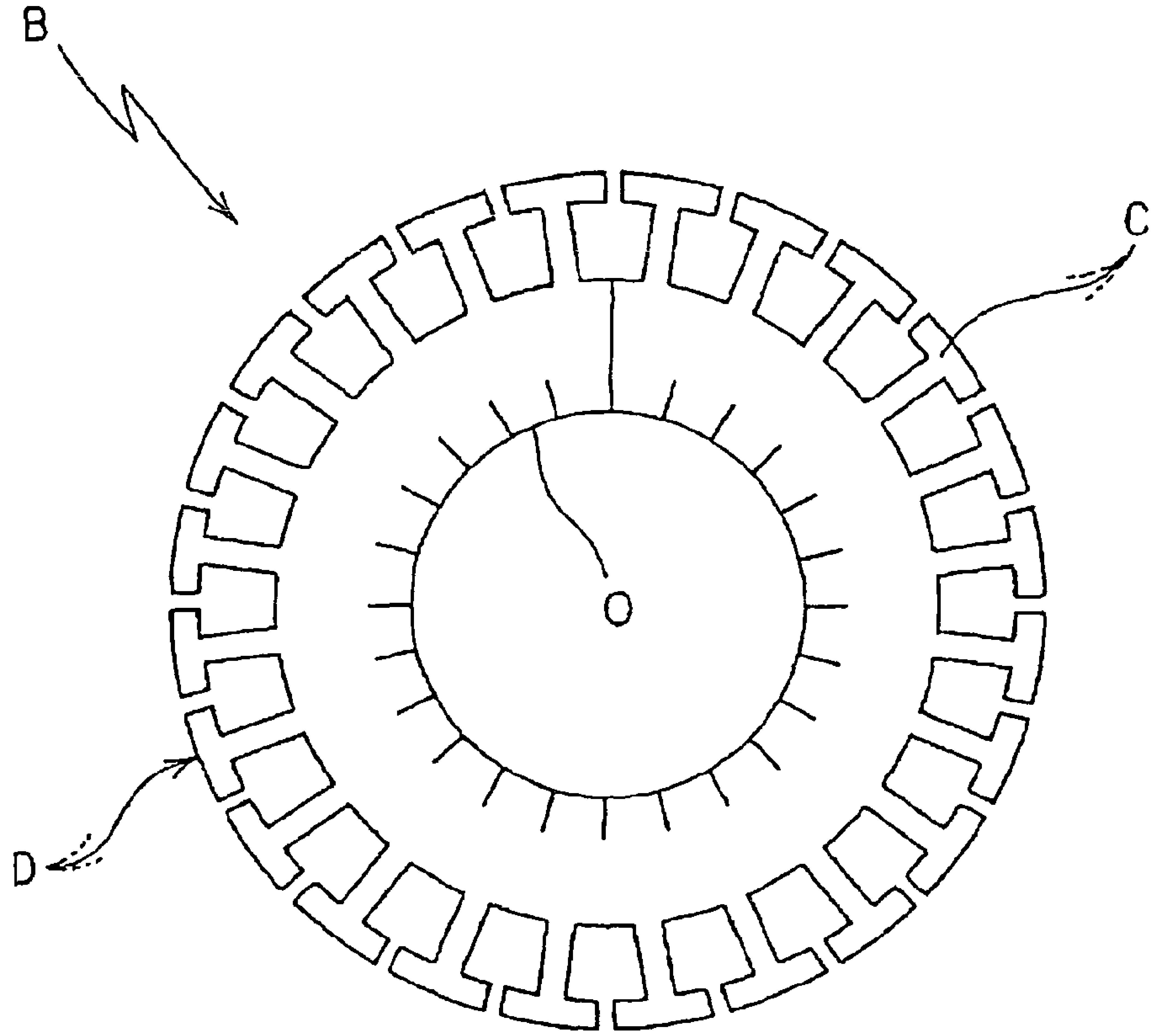


Fig. 66B

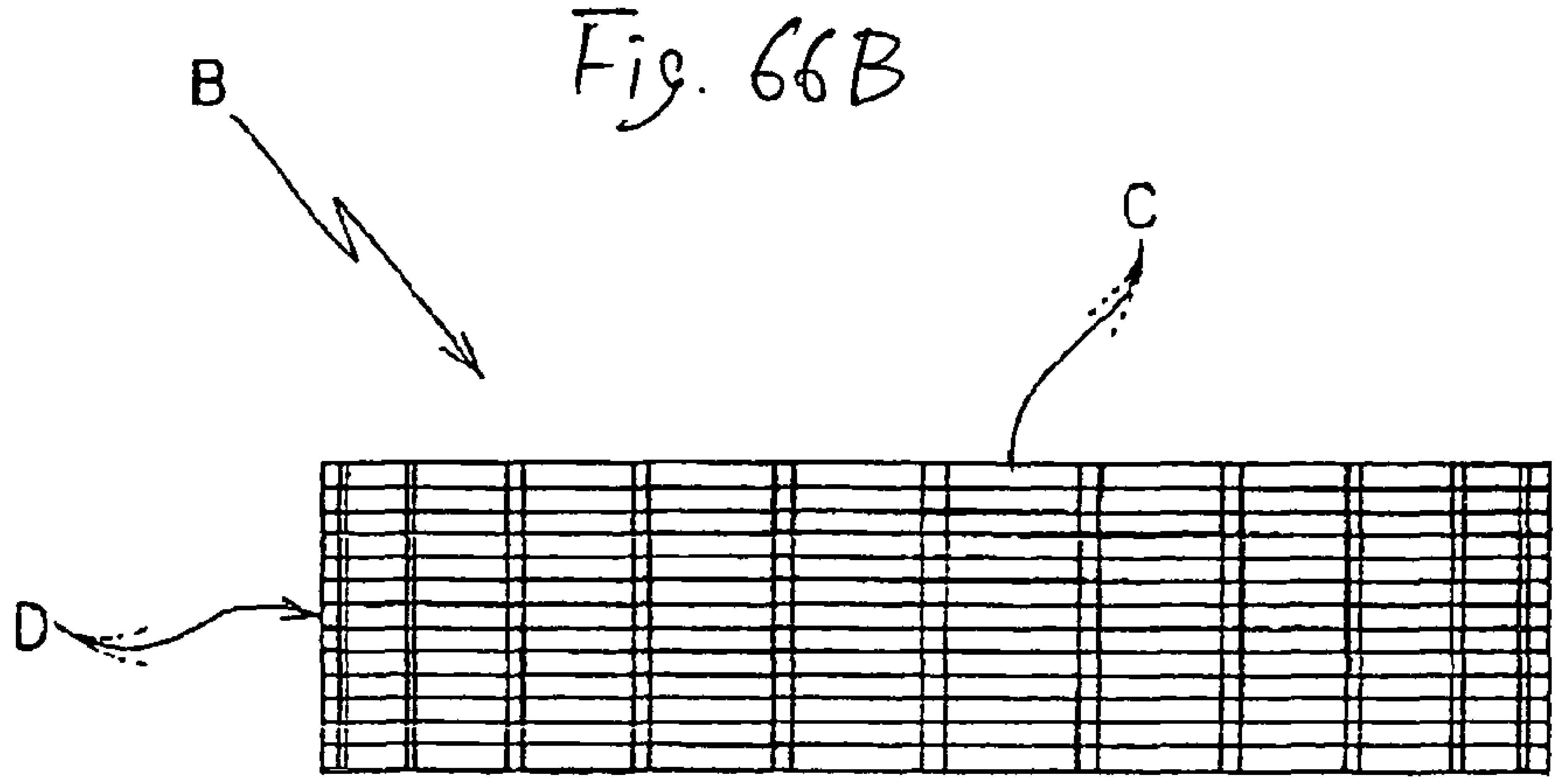


Fig. 67A

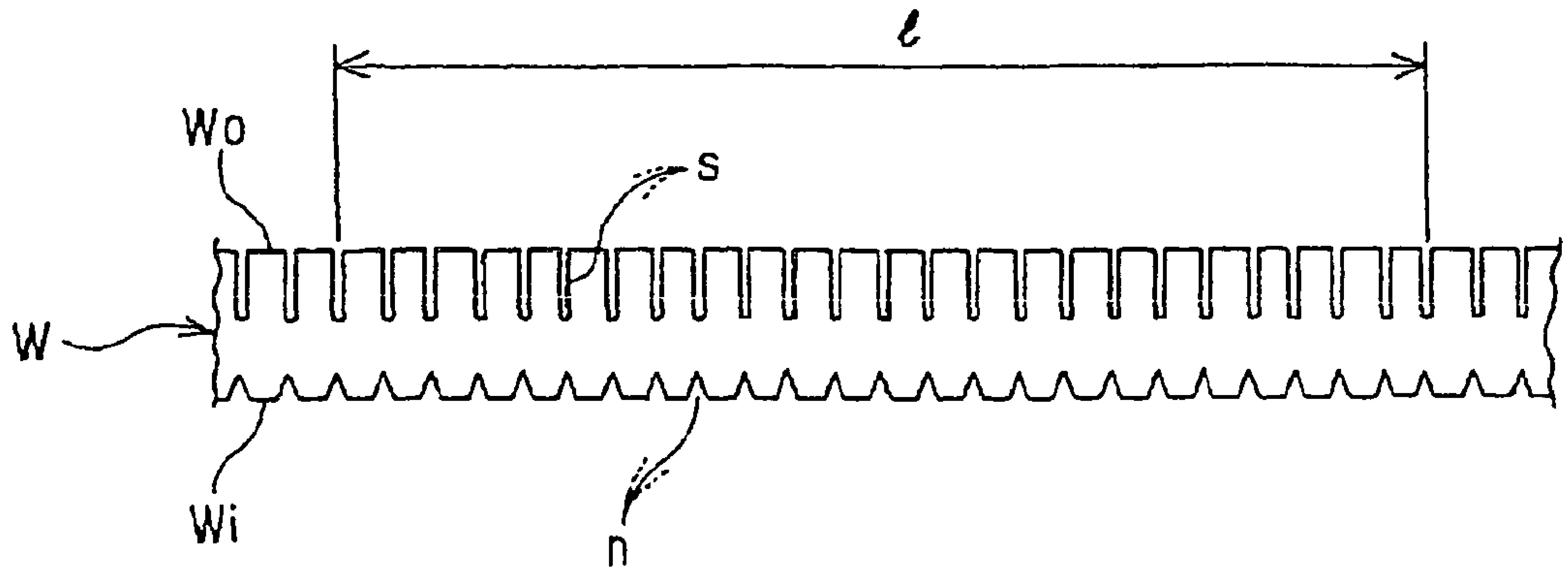


Fig. 67B

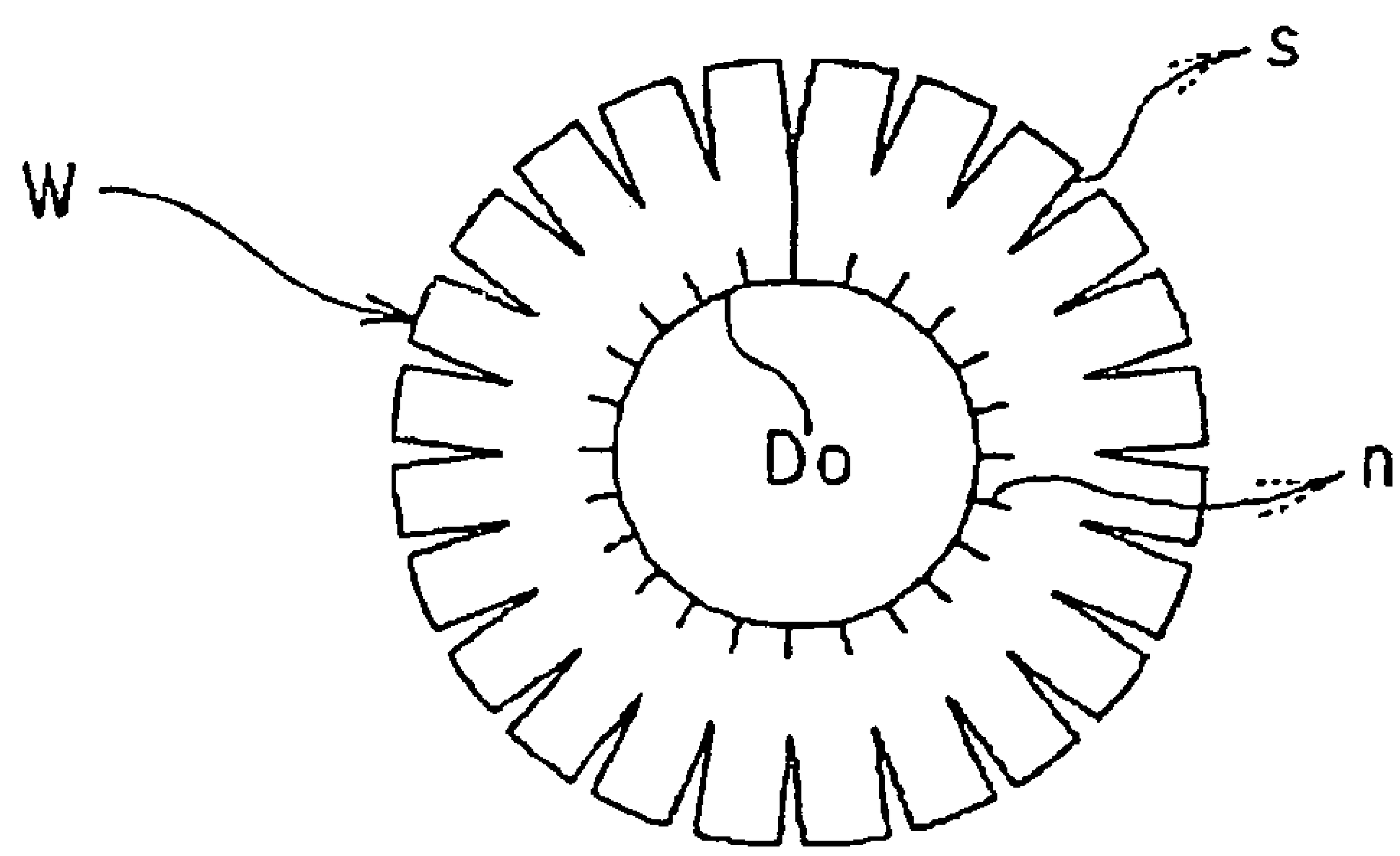
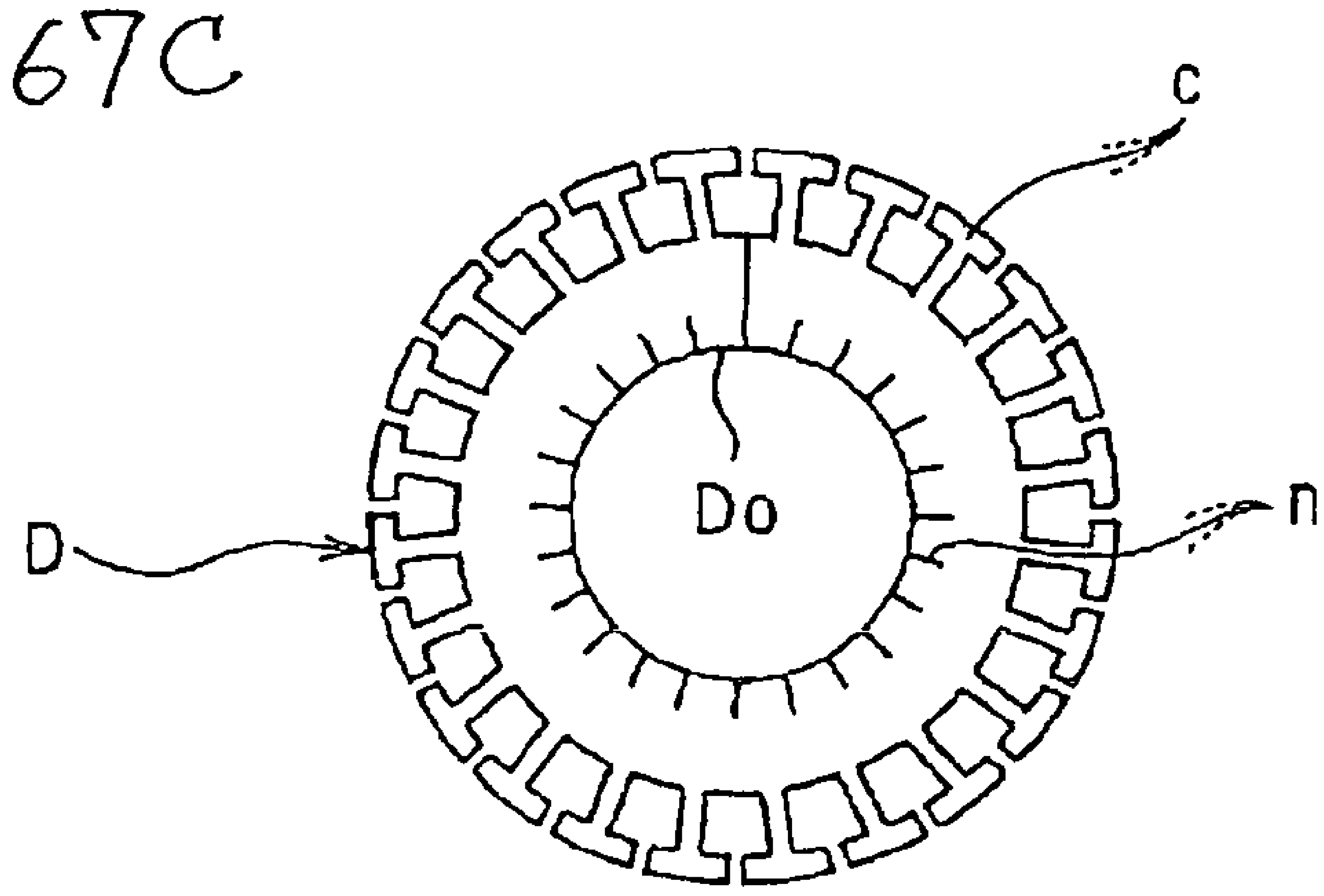


Fig. 67C



METHOD OF MANUFACTURING LAMINATED CORE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a divisional of application Ser. No. 10/573,867, filed Mar. 29, 2006, now U.S. Pat. No. 7,698,803, issued Apr. 20, 2010.

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a method of manufacturing a laminated core, and more particularly, to a method of manufacturing a laminated core by winding and laminating band-shaped core pieces in a spiral shape and coupling the band-shaped core pieces to each other in a caulking manner.

DESCRIPTION OF THE RELATED ART

Large-sized ones are used as a laminated core built in a driving electric motor generating high power. Since a large-sized manufacturing apparatus (molding apparatus) is required for manufacturing the large-sized laminated core such as a laminated stator core, the increase in cost is caused. Further, since when a large-sized stator core piece is formed through punching, wide scraped portions are generated from the inside. Accordingly, a blanking yield of a core material is remarkably reduced.

In order to solve the above-mentioned problem, there has been suggested a method of manufacturing a laminated stator core by forming band-shaped core pieces having a shape that the laminated stator core is developed in a straight line by punching a metal plate, and winding and laminating the band-shaped core pieces in a spiral shape (for example, see Patent Document 1 and Patent Document 2).

The laminated stator core A shown in FIG. **62**A includes a yoke Y having a cylinder shape and a predetermined number of protrusions T, T, . . . protruded in the diameter direction from the yoke Y. The laminated stator core is manufactured, as shown in FIG. **63**A, by winding and laminating a band-shaped core piece S, that is, a band-shaped core piece S in which magnetic pole portions St, St, . . . are formed in the inner circumferential edge of a yoke portion Sy extending in a line shape, around the outer circumference of a guide G, and caulking the band-shaped core pieces S, S, . . . wound and laminated with each other by vertically pressing them or fixing them by welding.

In the method of manufacturing a laminated stator core, since a large-sized manufacturing apparatus (molding apparatus) is not necessary and the blanking yield of the core material is enhanced, it is possible to prevent the increase in manufacturing cost.

Patent Document 1: Japanese Unexamined Patent Publication No. 11-299136

Patent Document 2: Japanese Unexamined Patent Publication No. 2000-224817

However, in the conventional manufacturing method described above, since the plane shape of the band-shaped core piece S constituting the laminated stator core A is very complex, it is difficult to wind the band-shaped core piece S in a circular shape due to deviation in deformation of each place at the time of winding it in a spiral shape or the like. In addition, since a departure can be easily generated between the laminated magnetic pole portions St, St, . . . constituting the magnetic poles T, shaping precision of the manufactured laminated stator core A is severely deteriorated.

In this way, when the shaping precision of the laminated stator core A is deteriorated, there is a problem that an air gap from a rotor (not shown) has to be set great and it is possible to accomplish high power and high torque with increase in size due to deterioration in efficiency.

In the conventional manufacturing method described above, when the band-shaped core pieces S, S, . . . wound are coupled to each other by welding, an eddy current loss in the manufactured laminated stator core A is increased. On the other hand, when the band-shaped core pieces S, S, . . . wound are coupled to each other in a caulking manner, the shaping precision of winding the band-shaped core pieces S, S, . . . is not good as described above. Accordingly, the coupling strength is decreased due to the gap generated between the laminated band-shaped core pieces S, thereby reducing the mechanical strength of the manufactured laminated stator core A.

In the conventional manufacturing method described above, since the plane shape of the band-shaped core piece S is very complex, the material yield of blanking the band-shaped core piece S is not good.

In the conventional manufacturing method described above, since the yoke Y and the magnetic poles T, T, . . . of the laminated stator core A are formed integrally with each other, it is difficult to perform the winding work of coils to the respective magnetic poles T, thereby causing deterioration in electrical characteristic due to disturbance of the coils.

As a technology for solving the above-mentioned problems, a method of manufacturing a laminated stator core is suggested by arranging and fixing laminated stator sub-bodies, which have a shape that the laminated stator core is divided in a unit of magnetic poles, in a ring shape inside a case (for example, see Patent Document 3).

The laminated stator core B shown in FIGS. **64** and **65** is manufactured as follows. First, a laminated stator sub-body C is formed by laminating a predetermined number of stator core sub-pieces Ca formed by punching a plate material and then a coil L is wound around the laminated stator sub-body C. Thereafter, a predetermined number of laminated stator sub-bodies C, C, . . . on which the coil L has been wound are arranged in a ring shape on the inner circumference of an inner case I having a cylinder shape in which a slit is formed in the axis direction and are temporarily held in this state. Subsequently, an outer case O is shrink-fitted to the outer circumference of the inner case I, thereby coupling the laminated stator sub-bodies C, C, . . . , the inner case I, and the outer case O to each other.

According to the conventional method of manufacturing such a laminated stator core, since the laminated stator core is divided into a predetermined number of laminated stator sub-bodies C, C, . . . , the yield of blanking the stator core sub-pieces Ca, Ca, . . . is enhanced and the winding work of a coil around the respective laminated stator sub-bodies C is performed very easily.

Patent Document 3: Japanese Unexamined Patent Publication No. 2002-51485

However, in the conventional manufacturing method described with reference to FIGS. **64** and **65**, since it is necessary to additionally prepare the inner case I and the outer case O which are manufactured through a particular process, along with the laminated stator sub-bodies C, C, . . . manufactured through punching, laminating, and caulking processes by the use of a molding apparatus, the processes of manufacturing the laminated stator core B are very complex. In addition, when a predetermined number of laminated stator sub-bodies C, C, . . . on which the coils L have been wound are arranged and temporarily held on the inner circumferential surface of the inner case I, a highly skilled hand is required for arranging the laminated stator sub-bodies C, C, . . . a complete circular shape. Accordingly, it cannot be told that the shaping precision of the manufactured laminated stator core B is satisfactory.

In the case that the above-mentioned method of manufacturing a laminated stator core is used for manufacturing a laminated stator core, since a laminated rotor core is generally smaller than the laminated stator core and it is very difficult to wind the band-shaped core pieces in a circular shape with a small curvature, the shaping precision of the manufactured laminated rotor core is deteriorated.

On the other hand, as another method of manufacturing a laminated rotor core, there is known a method of manufacturing a laminated rotor core by laminating a predetermined number of core pieces which are formed by winding band-shaped core pieces in a ring shape, not in a spiral shape (see Patent Document 4).

Specifically, the laminated rotor core B shown in FIG. **66** has a rotation shaft fitting hole (shaft hole) O at the center thereof and protrusions C, C, . . . at the outer circumference thereof. As shown in FIG. **67**, the laminated stator core B is manufactured by winding a band-shaped plate W extending straightly, in which cut portions n, n, . . . are formed in the inner circumferential edge Wi and slits s, s, . . . are formed in the outer circumferential edge Wo, by a predetermined length l in a ring shape to form the shaft hole Do at the center thereof, forming the magnetic pole portions c, c, . . . by punching the peripheries of the slits s to form a sheet of a rotor core piece D, and laminating and fixing a predetermined number of the rotor core pieces D to each other.

Patent Document 4: Japanese Unexamined Patent Publication No. 7-87714

In the method of manufacturing a laminated rotor core shown in FIGS. **66** and **67**, since the rotor core piece D is formed by winding the band-shaped plate W, the material yield of the metal plate is greatly enhanced.

However, since the shaft hole Do of the respective rotor core pieces D constituting the laminated rotor core B has a polygonal shape consisting of segments formed by dividing the inner circumference edge Wi of the band-shaped plate W by the cut portions n, a re-grinding process using a broaching machine or the like should be necessarily performed to the rotation shaft fitting hole O so as to fitting a rotation shaft (not shown) into the rotation shaft fitting hole (shaft hole) O of the laminated rotor core B in which a predetermined number of rotor core pieces D are laminated. Accordingly, the processes of manufacturing the laminated rotor core as a complete product are complex, thereby causing deterioration in productivity.

In the above-mentioned method of manufacturing the laminated rotor core, since the respective rotor core pieces D are formed in a ring shape by winding them one by one, it is difficult to enhance the productivity of the laminated rotor core in which a predetermined number of rotor core pieces D.

DISCLOSURE OF INVENTION

Problems to be Solved by the Invention

As described above, it is difficult to manufacture a large-sized laminated core excellent in shaping precision and electrical characteristic.

An object of the present invention is to provide a method of manufacturing a laminated core excellent in shaping precision and electrical characteristic in view of the above-mentioned problems.

According to a first aspect of the present invention, there is provided a method of manufacturing a laminated stator core, the method comprising: forming a band-shaped yoke core piece having a shape that a yoke of the laminated stator core is developed in a straight line and having concave connection portions in the inner circumferential edge thereof by punching a metal plate; forming a laminated yoke body by winding and laminating the band-shaped yoke core piece in a spiral shape and coupling the laminated band-shaped yoke core piece in a caulking manner; forming a magnetic core piece having a convex connection portion at the base end thereof by punching a metal plate; forming a laminated magnetic body by laminating and coupling a predetermined number of the magnetic core pieces to each other in a caulking manner; and coupling the laminated yoke body and the laminated magnetic body to each other by winding a coil around the laminated magnetic body and then inserting the convex connection portions into the concave connection portions.

According to a second aspect of the present invention, there is provided a method of manufacturing a laminated stator core, the method comprising: forming a band-shaped yoke core piece having a shape that a yoke of the laminated stator core is developed in a straight line and having concave connection portions in the inner circumferential edge thereof by punching a metal plate; forming a laminated yoke body by locally pressing the outer circumferential edge of the band-shaped yoke core piece to roll it in a longitudinal direction, then winding and laminating the band-shaped yoke core piece in a spiral shape, and coupling the laminated band-shaped yoke core piece in a caulking manner; forming a magnetic core piece having a convex connection portion at the base end thereof by punching a metal plate; forming a laminated magnetic body by laminating and coupling a predetermined number of the magnetic core pieces to each other in a caulking manner; and coupling the laminated yoke body and the laminated magnetic body to each other by winding a coil around the laminated magnetic body and then inserting the convex connection portions into the concave connection portions.

According to a third aspect of the present invention, the method of the first or second aspect may further comprise correcting the shape of the laminated yoke body by applying a diameter enlarging force from the inner circumference of the laminated yoke body, after the forming the laminated yoke body and before the coupling the laminated magnetic bodies to the laminated yoke body.

According to a fourth aspect of the present invention, there is provided a method of manufacturing a laminated stator core, the method comprising: forming a band-shaped yoke core piece having a shape that a yoke of the laminated stator core is developed in a straight line and having concave connection portions in the inner circumferential edge thereof by punching a metal plate; forming a laminated yoke body by winding and laminating the band-shaped yoke core piece in a spiral shape, coupling the laminated band-shaped yoke core piece in a caulking manner by the use of caulking portions formed in advance, and locally pressing the caulking portions or peripheries of the caulking portions including the caulking portions; forming a magnetic core piece having a convex connection portion at the base end thereof by punching a metal plate; forming a laminated magnetic body by laminating and coupling a predetermined number of the magnetic core pieces to each other in a caulking manner; and coupling the laminated yoke body and the laminated magnetic body to each other by winding a coil around the laminated magnetic body and then inserting the convex connection portions into the concave connection portions.

According to a fifth aspect of the present invention, in the method of the fourth aspect, the area where the periphery of each caulking portion including the caulking portion is locally pressed may be an area which is widened from the caulking portion toward the outer circumferential edge of each band-shaped yoke core piece

According to a sixth aspect of the present invention, there is provided a method of manufacturing a laminated stator core in which a laminated magnetic body formed by laminating a magnetic core piece in a caulking manner is fitted to a laminated yoke body formed by winding and laminating a band-shaped yoke core piece in a caulking manner, the method comprising: forming the band-shaped yoke core piece having a shape that a yoke of the laminated stator core is developed in a straight line by punching a metal plate, wherein concave connection portions are formed in the inner circumferential edge thereof and arc-shaped caulking portions are arranged with a constant pitch in a plane shape curved in the winding direction; forming the laminated yoke body by winding and laminating the band-shaped yoke core piece in a spiral shape and inserting caulking tongues of the arc-shaped caulking portions into caulking grooves of the arc-shaped caulking portion in a lower layer to couple them in a caulking manner; forming a magnetic core piece having a convex connection portion at the base end thereof by punching a metal plate; forming a laminated magnetic body by laminating and coupling a predetermined number of the magnetic core pieces to each other in a caulking manner; and coupling the laminated yoke body and the laminated magnetic body to each other by winding a coil around the laminated magnetic body and then inserting the convex connection portions into the concave connection portions.

According to a seventh aspect of the present invention, there is provided a method of manufacturing a laminated stator core, the method comprising: forming a band-shaped yoke core sub-piece having a shape that an outer half is developed in a straight line when a yoke portion of the laminated stator core is divided into two halves in the width direction by punching a metal plate; forming an outer laminated yoke body by winding and laminating the band-shaped yoke core sub-piece in a spiral shape and coupling it in a caulking manner; forming an inner yoke-attachment magnetic core sub-piece having an inner yoke sub-portion obtained by dividing the inner half in a unit of magnetic poles when the yoke portion of the laminated stator core is divided into two halves in the width direction, by punching a metal plate; forming an inner yoke-attachment laminated magnetic sub-body by laminating and coupling a predetermined number of the inner yoke-attachment magnetic core sub-pieces to each other in a caulking manner; forming an intermediate assembly in which the inner yoke sub-portions form a ring shape by winding a coil on the inner yoke-attachment laminated magnetic sub-body and connecting the ends of the inner yoke sub-portions in a predetermined number of the inner yoke-attachment laminated magnetic sub-bodies to each other; and coupling the inner yoke-attachment laminated magnetic sub-bodies to the outer laminated yoke body by shrink-fitting the outer laminated yoke body to the outer circumference of the intermediate assembly.

According to an eighth aspect of the present invention, there is provided a method of manufacturing a laminated stator core, the method comprising: forming a band-shaped yoke core sub-piece having a shape that an outer half is developed in a straight line when a yoke portion of the laminated stator core is divided into two halves in the width direction and having concave connection portions in the inner circumferential edge thereof by punching a metal plate; forming an outer laminated yoke body by winding and laminating the band-shaped yoke core sub-piece in a spiral shape and coupling it in a caulking manner; forming an inner yoke-attachment magnetic core sub-piece having a convex connection portion at the back side of an inner yoke sub-portion obtained by dividing the inner half in a unit of magnetic poles when the yoke portion of the laminated stator core is divided into two halves in the width direction, by punching a metal plate; forming an inner yoke-attachment laminated magnetic sub-body by laminating and coupling a predetermined number of the inner yoke-attachment magnetic core sub-pieces to each other in a caulking manner; and coupling the inner yoke-attachment laminated magnetic sub-body to the outer laminated yoke body by winding a coil on the inner yoke-attachment laminated magnetic sub-body and inserting the convex connection portion into the concave connection portion.

According to a ninth aspect of the present invention, there is provided a method of manufacturing a laminated stator core, the method comprising: forming a band-shaped yoke core sub-piece having a shape that an outer half is developed in a straight line when a yoke portion of the laminated stator core is divided into two halves in the width direction and having concave connection portions in the inner circumferential edge thereof by punching a metal plate; forming an outer laminated yoke body by winding and laminating the band-shaped yoke core sub-piece in a spiral shape and coupling it in a caulking manner; forming an inner yoke-attachment magnetic core sub-piece having a convex connection portion at the back side of an inner yoke sub-portion obtained by dividing the inner half in a unit of magnetic poles when the yoke portion of the laminated stator core is divided into two halves in the width direction, by punching a metal plate; forming an inner yoke-attachment laminated magnetic sub-body by laminating and coupling a predetermined number of the inner yoke-attachment magnetic core sub-pieces to each other in a caulking manner; and forming an inner yoke-attachment laminated magnetic sub-body by laminating and coupling a predetermined number of the inner yoke-attachment magnetic core sub-pieces to each other in a caulking manner; forming an intermediate assembly in which the inner yoke sub-portions form a ring shape by winding a coil on the inner yoke-attachment laminated magnetic sub-body and connecting the ends of the inner yoke sub-portions in a predetermined number of the inner yoke-attachment laminated magnetic sub-bodies to each other; and coupling the inner yoke-attachment laminated magnetic sub-bodies to the outer laminated yoke body by shrink-fitting the outer laminated yoke body to the outer circumference of the intermediate assembly and inserting the convex connection portions into the concave connection portions.

According to a tenth aspect of the present invention, there is provided a method of manufacturing a laminated rotor core by coupling a band-shaped core piece, which is wound and laminated in a spiral shape, in a caulking manner, the method comprising: forming a band-shaped core piece having a shape that the laminated rotor core is developed in a straight line by punching a metal plate, wherein cut portions are formed with a predetermined pitch in the inner circumferential edge, the inner circumferential edge between the adjacent cut portions is formed in an arc shape corresponding to the inner circumference of a shaft hole, and magnet fitting holes are formed with a predetermined pitch in an intermediate portion in the width direction; and winding and laminating the band-shaped core piece in a spiral shape while locally pressing and stretching the outer circumferential edge of the band-shaped core piece, and coupling the laminated band-shaped core piece in a caulking manner.

According to an eleventh aspect of the present invention, there is provided a method of manufacturing a laminated rotor core by coupling a band-shaped core piece, which is wound and laminated in a spiral shape, in a caulking manner, the method comprising: forming a band-shaped core piece having a shape that the laminated rotor core is developed in a straight line by punching a metal plate, wherein cut portions are formed with a predetermined pitch in the inner circumferential edge, the inner circumferential edge between the adjacent cut portions is formed in an are shape corresponding to the inner circumference of a shaft hole, and diecast metal filling holes are formed with a predetermined pitch in an intermediate portion in the width direction; and winding and laminating the band-shaped core piece in a spiral shape while locally pressing and stretching the outer circumferential edge of the band-shaped core piece, and coupling the laminated band-shaped core piece in a caulking manner.

Effect of the Invention

In the first aspect of the present invention, since the laminated yoke body constituting the yoke of the laminated stator core and the laminated magnetic body constituting a magnetic pole of the laminated stator core are independently formed, the band-shaped yoke core piece constituting the laminated yoke body has a band shape with a small width, and the concave connection portions are formed in the inner circumferential edge of the band-shaped yoke core piece, bending processability of the band-shaped yoke core piece is greatly enhanced to be satisfactory. Accordingly, it is possible to form the laminated yoke body, which is formed by winding the band-shaped yoke core piece, in a circular shape.

Since the laminated magnetic body is formed by laminating a predetermined number of magnetic core pieces in a caulking manner, the laminated magnetic body is manufactured without departure between the laminated magnetic core pieces. Accordingly, the laminated stator core in which a predetermined number of laminated magnetic bodies are coupled to the laminated yoke body has very excellent shaping precision.

In addition, since the laminated magnetic body is formed independently of the laminated yoke body, the winding work of winding a coil on the laminated magnetic body becomes very easy. Accordingly, it is possible to wind a coil with a high density and an excellent proportion.

As a result, according to the first aspect of the present invention, it is possible to manufacture a laminated stator core excellent in shaping precision and electrical characteristic.

In the second aspect of the present invention, since the laminated yoke body constituting the yoke of the laminated stator core and the laminated magnetic body constituting a magnetic pole of the laminated stator core are independently formed, the band-shaped yoke core piece constituting the laminated yoke body has a band shape with a small width, and the concave connection portions are formed in the inner circumferential edge of the band-shaped yoke core piece, bending processability of the band-shaped yoke core piece is greatly enhanced to be satisfactory. Accordingly, it is possible to form the laminated yoke body, which is formed by winding the band-shaped yoke core piece, in a circular shape.

By locally pressing the outer circumferential edge of the band-shaped yoke core piece to roll the band-shaped yoke core piece in a longitudinal direction before winding the band-shaped yoke core piece in a spiral shape, it is possible to easily wind the band-shaped yoke core piece. Accordingly, the degree of circularity of the laminated yoke body formed by winding the band-shaped yoke core piece is enhanced and thus the shaping precision of the laminated yoke body is enhanced.

Since the laminated magnetic body is formed by laminating a predetermined number of magnetic core pieces in a caulking manner, the laminated magnetic body is manufactured without departure between the laminated magnetic core pieces. Accordingly, the laminated stator core in which a predetermined number of laminated magnetic bodies are coupled to the laminated yoke body has very excellent shaping precision.

In addition, since the laminated magnetic body is formed independently of the laminated yoke body, the winding work of winding a coil on the laminated magnetic body becomes very easy. Accordingly, it is possible to wind a coil with a high density and an excellent proportion.

In this way, by the use of the second method of manufacturing a laminated stator core according to the present invention, it is possible to manufacture a laminated stator core excellent in shaping precision and electrical characteristic.

In the third aspect of the present invention, since the shape is corrected by applying the diameter enlarging force from the inner circumference to the laminated yoke body formed by winding the band-shaped yoke core piece, it is possible to enhance the degree of circularity of the laminated yoke body and thus to manufacture a laminated stator core with excellent shaping precision.

In the fourth aspect of the present invention, since the laminated yoke body constituting the yoke of the laminated stator core and the laminated magnetic body constituting a magnetic pole of the laminated stator core are independently formed, the band-shaped yoke core piece constituting the laminated yoke body has a band shape with a small width, and the concave connection portions are formed in the inner circumferential edge of the band-shaped yoke core piece, bending processability of the band-shaped yoke core piece is greatly enhanced to be satisfactory. Accordingly, it is possible to form the laminated yoke body, which is formed by winding the band-shaped yoke core piece, in a circular shape.

By coupling the band-shaped yoke core piece wound and laminated in a spiral shape by the use of the caulking portions in a caulking manner and locally pressing the periphery of the caulking portions including the caulking portions, the thickness of the band-shaped yoke core piece is locally reduced. Accordingly, the shaping property at the time of winding the band-shaped yoke core piece is further enhanced and a laminated yoke body with a large coupling strength can be obtained in which a gap is not formed between the laminated band-shaped yoke core pieces.

Since the laminated magnetic body is formed by laminating a predetermined number of magnetic core pieces in a caulking manner, the laminated magnetic body is manufactured without departure between the laminated magnetic core pieces. Accordingly, the laminated stator core in which a predetermined number of laminated magnetic bodies are coupled to the laminated yoke body has very excellent shaping precision.

In addition, since the laminated magnetic body is formed independently of the laminated yoke body, the winding work of winding a coil on the laminated magnetic body becomes very easy. Accordingly, it is possible to wind a coil with a high density and an excellent proportion.

As a result, according to the fourth aspect of the present invention, it is possible to manufacture a laminated stator core excellent in shaping precision, mechanical strength, and electrical characteristic.

In the fifth aspect of the present invention, by locally pressing the area widened from the caulking portions toward the outer circumferential edge of the band-shaped yoke core piece, it is possible to easily wind the band-shaped yoke core piece. Accordingly, the shape of the laminated yoke body formed by winding the band-shaped yoke core piece becomes very good.

In the sixth aspect of the present invention, since the laminated yoke body constituting the yoke of the laminated stator core and the laminated magnetic body constituting a magnetic pole of the laminated stator core are independently formed, the band-shaped yoke core piece constituting the laminated yoke body has a band shape with a small width, and the concave connection portions are formed in the inner circumferential edge of the band-shaped yoke core piece, bending processability of the band-shaped yoke core piece is greatly enhanced to be satisfactory. Accordingly, it is possible to form the laminated yoke body, which is formed by winding the band-shaped yoke core piece, in a circular shape.

By arranging the arc-shaped caulking portions formed in the band-shaped yoke core piece in a plane shape curved in the winding direction, the caulking tongues of the arc-shaped caulking portions in an upper layer are inserted into the caulking grooves of the arc-shaped caulking portions in a lower layer so as to induce the winding of the band-shaped yoke core piece at the time of winding and laminating the band-shaped yoke core piece in a spiral shape. Accordingly, the shaping property of the band-shaped yoke core piece at the time of winding is enhanced and it is thus possible to form the laminated yoke body in a circular shape.

Since the laminated magnetic body is formed by laminating a predetermined number of magnetic core pieces in a caulking manner, the laminated magnetic body is manufactured without departure between the laminated magnetic core pieces. Accordingly, the laminated stator core in which a predetermined number of laminated magnetic bodies are coupled to the laminated yoke body has very excellent shaping precision.

In addition, since the laminated magnetic body is formed independently of the laminated yoke body, the winding work of winding a coil on the laminated magnetic body becomes very easy. Accordingly, it is possible to wind a coil with a high density and an excellent proportion.

As a result, according to the sixth aspect of the present invention, it is possible to manufacture a laminated stator core excellent in shaping precision and electrical characteristic.

In the seventh aspect of the present invention, since the outer laminated yoke body constituting the outer yoke of the laminated stator core and the inner yoke-attachment laminated magnetic sub-body constituting the inner yoke and a magnetic pole of the laminated stator core are independently formed, and the band-shaped yoke core sub-piece constituting the outer laminated yoke body has a band shape with a small width, the bending processability of the band-shaped yoke core sub-piece is greatly enhanced to be satisfactory. Accordingly, it is possible to form the outer laminated yoke body, which is formed by winding the band-shaped yoke core sub-piece, in a circular shape.

Since the inner yoke-attachment laminated magnetic sub-body is formed by laminating a predetermined number of inner yoke-attachment magnetic core sub-pieces in a caulking manner, the inner yoke-attachment laminated magnetic sub-body is manufactured without departure between the laminated inner yoke-attachment magnetic core sub-pieces. Accordingly, the laminated stator core in which a predetermined number of inner yoke-attachment laminated magnetic sub-bodies are coupled to the outer laminated yoke body has very excellent shaping precision.

Since the outer laminated yoke body and the inner yoke-attachment laminated magnetic sub-body are strongly and satisfactorily coupled to each other by means of shrink-fitting, the shaping precision of the laminated stator core is very excellent.

Since the band-shaped yoke core sub-piece constituting the outer laminated yoke body and the inner yoke-attachment laminated magnetic core sub-piece constituting the inner yoke-attachment laminated magnetic sub-body are independently blanked, it is possible to form the band-shaped yoke core sub-piece and the inner yoke-attachment magnetic core sub-piece with an excellent material yield.

In addition, since the inner yoke-attachment laminated magnetic sub-body is formed independently of the outer laminated yoke body, the winding work of winding a coil on the inner yoke-attachment laminated magnetic sub-body becomes very easy. Accordingly, it is possible to wind a coil with a high density and an excellent proportion.

As a result, according to the seventh aspect of the present invention, it is possible to manufacture a laminated stator core excellent in material yield, shaping precision and electrical characteristic.

In the eighth aspect of the present invention, since the outer laminated yoke body constituting the outer yoke of the laminated stator core and the inner yoke-attachment laminated magnetic sub-body constituting the inner yoke and a magnetic pole of the laminated stator core are independently formed, the band-shaped yoke core sub-piece constituting the outer laminated yoke body has a band shape with a small width, and the concave connection portions are formed in the inner circumferential edge of the band-shaped yoke core sub-piece, the bending processability of the band-shaped yoke core sub-piece is greatly enhanced to be satisfactory. Accordingly, it is possible to form the outer laminated yoke body, which is formed by winding the band-shaped yoke core sub-piece, in a circular shape.

Since the inner yoke-attachment laminated magnetic sub-body is formed by laminating a predetermined number of inner yoke-attachment magnetic core sub-pieces in a caulking manner, the inner yoke-attachment laminated magnetic sub-body is manufactured without departure between the laminated inner yoke-attachment magnetic core sub-pieces. Accordingly, the laminated stator core in which a predetermined number of inner yoke-attachment laminated magnetic sub-bodies are coupled to the outer laminated yoke body has very excellent shaping precision.

Since the outer laminated yoke body and the inner yoke-attachment laminated magnetic sub-body are strongly and satisfactorily coupled to each other by inserting the convex connection portions of the inner yoke-attachment laminated magnetic sub-bodies into the concave connection portions of the outer laminated yoke body, the shaping precision of the laminated stator core is very excellent.

Since the band-shaped yoke core sub-piece constituting the outer laminated yoke body and the inner yoke-attachment laminated magnetic core sub-piece constituting the inner yoke-attachment laminated magnetic sub-body are independently blanked, it is possible to form the band-shaped yoke core sub-piece and the inner yoke-attachment magnetic core sub-piece with an excellent material yield.

In addition, since the inner yoke-attachment laminated magnetic sub-body is formed independently of the outer laminated yoke body, the winding work of winding a coil on the inner yoke-attachment laminated magnetic sub-body becomes very easy. Accordingly, it is possible to wind a coil with a high density and an excellent proportion.

As a result, according to the eighth aspect of the present invention, it is possible to manufacture a laminated stator core excellent in material yield, shaping precision and electrical characteristic.

In the ninth aspect of the present invention, since the outer laminated yoke body constituting the outer yoke of the laminated stator core and the inner yoke-attachment laminated magnetic sub-body constituting the inner yoke and a magnetic pole of the laminated stator core are independently formed, the band-shaped yoke core sub-piece constituting the outer laminated yoke body has a band shape with a small width, and the concave connection portions are formed in the inner circumferential edge of the band-shaped yoke core sub-piece, the bending processability of the band-shaped yoke core sub-piece is greatly enhanced to be satisfactory. Accordingly, it is possible to form the outer laminated yoke body, which is formed by winding the band-shaped yoke core sub-piece, in a circular shape.

Since the inner yoke-attachment laminated magnetic sub-body is formed by laminating a predetermined number of inner yoke-attachment magnetic core sub-pieces in a caulking manner, the inner yoke-attachment laminated magnetic sub-body is manufactured without departure between the laminated inner yoke-attachment magnetic core sub-pieces. Accordingly, the laminated stator core in which a predetermined number of inner yoke-attachment laminated magnetic sub-bodies are coupled to the outer laminated yoke body has very excellent shaping precision.

Since the outer laminated yoke body and the inner yoke-attachment laminated magnetic sub-body are strongly and satisfactorily coupled to each other by inserting the convex connection portions of the inner yoke-attachment laminated magnetic sub-bodies into the concave connection portions of the outer laminated yoke body, the shaping precision of the laminated stator core is very excellent.

Since the outer laminated yoke body and the inner yoke-attachment laminated magnetic sub-body are strongly and satisfactorily coupled to each other by shrink-fitting the outer laminated yoke body to the outer circumference of the intermediate assembly to insert the convex connection portions into the concave connection portions, the shaping precision of the laminated, stator core is very excellent.

Since the band-shaped yoke core sub-piece constituting the outer laminated yoke body and the inner yoke-attachment laminated magnetic core sub-piece constituting the inner yoke-attachment laminated magnetic sub-body are independently blanked, it is possible to form the band-shaped yoke core sub-piece and the inner yoke-attachment magnetic core sub-piece with an excellent material yield.

In addition, since the inner yoke-attachment laminated magnetic sub-body is formed independently of the outer laminated yoke body, the winding work of winding a coil on the inner yoke-attachment laminated magnetic sub-body becomes very easy. Accordingly, it is possible to wind a coil with a high density and an excellent proportion.

As a result, according to the ninth aspect of the present invention, it is possible to manufacture a laminated stator core excellent in material yield, shaping precision, and electrical characteristic.

In the tenth aspect of the present invention, when winding the band-shaped core piece in a spiral shape, the inner circumferential edge is bent without a surface compression by forming the cut portions with a predetermined pitch, the bending processability of the outer circumferential edge is enhanced by locally pressing the outer circumferential edge of the band-shaped core piece to roll the band-shaped core piece, and the bending processability of an intermediate portion in the width direction is enhanced by forming the magnet fitting holes. Accordingly, it is possible to wind the band-shaped core piece in a circular shape and thus to manufacture a laminated rotor core excellent in shaping precision.

In the tenth aspect of the present invention, since the laminated rotor core is manufactured by winding and laminating the band-shaped core piece in a spiral shape, it is possible to greatly enhance the productivity of the laminated rotor core, in comparison with the conventional manufacturing method in which a rotor core formed by winding a band-shaped plate in a circular shape is laminated sheet by sheet.

In addition, since the shaft hole of the laminated rotor core formed by winding the band-shaped core piece has a circular shape by forming the inner circumferential edge between the cut portions in the band-shaped core piece in an arc shape corresponding to the inner circumference of the shaft hole, a re-grinding process is not necessary. Accordingly, it is possible to greatly improve the productivity of the laminated rotor core.

As a result, according to the tenth aspect of the present invention, it is possible to manufacture a laminated rotor core with saved energy, high power, high efficiency, excellent shaping precision, and high productivity.

In the eleventh aspect of the present invention, when winding the band-shaped core piece in a spiral shape, the inner circumferential edge is bent without a surface compression by forming the cut portions with a predetermined pitch, the bending processability of the outer circumferential edge is enhanced by locally pressing the outer circumferential edge of the band-shaped core piece to roll the band-shaped core piece, and the bending processability of an intermediate portion in the width direction is enhanced by forming the diecast metal filling holes. Accordingly, it is possible to wind the band-shaped core piece in a circular shape and thus to manufacture a laminated rotor core excellent in shaping precision.

In the eleventh aspect of the present invention, since the laminated rotor core is manufactured by winding and laminating the band-shaped core piece in a spiral shape, it is possible to greatly enhance the productivity of the laminated rotor core, in comparison with the conventional manufacturing method in which a rotor core formed by winding a band-shaped plate in a circular shape is laminated sheet by sheet.

In addition, since the shaft hole of the laminated rotor core formed by winding the band-shaped core piece has a circular shape by forming the inner circumferential edge between the cut portions in the band-shaped core piece in an arc shape corresponding to the inner circumference of the shaft hole, a re-grinding process is not necessary. Accordingly, it is possible to greatly improve the productivity of the laminated rotor core.

As a result, according to the eleventh aspect of the present invention, it is possible to manufacture a laminated rotor core with saved energy, high power, high efficiency, excellent shaping precision, and high productivity.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1**A and **1**B are an entire plan view and an entire side view illustrating a laminated stator core manufactured by the use of a method according to an embodiment of the present invention, respectively.

FIGS. **2**A and **2**B are perspective views illustrating a laminated magnetic body and a laminated yoke body constituting the laminated stator core shown in FIG. **1**.

FIGS. **3**A and **3**B are conceptual diagrams illustrating a procedure of manufacturing a laminated yoke body in the laminated stator core shown in FIG. **1**.

FIG. **4** is a conceptual diagram illustrating a procedure of manufacturing a laminated yoke body in the laminated stator core shown in FIG. **1**.

FIGS. **5**A, **5**B, and **5**C are conceptual diagrams illustrating a procedure of manufacturing a laminated magnetic body in the laminated stator core shown in FIG. **1**.

FIGS. **6**A and **6**B are conceptual diagrams illustrating a procedure of manufacturing the laminated stator core shown in FIG. **1**.

FIGS. **7**A and **7**B are partial plan views illustrating modifications of a concave connection portion in the laminated yoke body.

FIGS. **8**A and **8**B are an entire plan view and an entire side view illustrating a laminated stator core manufactured by the use of a method according to another embodiment of the present invention, respectively.

FIGS. **9**A and **9**B are entire plan views illustrating a laminated magnetic body of the laminated stator core manufactured according to another embodiment of the present invention.

FIGS. **10**A and **10**B are conceptual diagrams illustrating a procedure of manufacturing a laminated yoke body in a laminated stator core manufactured by the use of a second method according to the present invention.

FIGS. **11**A and **11**B are a cross-sectional view taken along Line XI-XI of FIG. **10** and an entire plan view illustrating the laminated yoke body.

FIGS. **12**A and **12**B are an entire plan view and an entire side view illustrating a laminated stator cores manufactured by the use of a method according to an embodiment of the present invention.

FIGS. **13**A and **13**B are perspective views illustrating a laminated magnetic body and a laminated yoke body constituting the laminated stator core shown in FIG. **12**.

FIGS. **14**A and **14**B are conceptual diagrams illustrating a procedure of manufacturing a laminated yoke body in the laminated stator core shown in FIG. **12**.

FIG. **15** is a partial plan view illustrating a caulking portion and a pressing portion of the laminated yoke body.

FIGS. **16**A, **16**B, and **16**C are conceptual diagrams illustrating a procedure of manufacturing a laminated magnetic body in the laminated stator core shown in FIG. **12**.

FIGS. **17**A and **17**B are conceptual diagrams illustrating a procedure of manufacturing the laminated stator core shown in FIG. **12**.

FIGS. **18**A and **18**B are an entire plan view and an entire side view illustrating a laminated stator core manufactured by the use of another method according to the present invention.

FIGS. **19**A and **19**B are perspective views illustrating appearances of a laminated magnetic body and a laminated yoke body constituting the laminated stator core shown in FIG. **18**.

FIGS. **21***a* and **20**B are conceptual diagrams illustrating a procedure of manufacturing a laminated yoke body in the laminated stator core shown in FIG. **18** and FIG. **20**C is a partial cross-sectional view illustrating an example of a band-shaped yoke core piece.

FIGS. **21**A and **21**B are a partial plan view and a partial cross-sectional view illustrating an arc-shaped caulking portion of a band-shaped yoke core piece.

FIGS. **22**A and **22**B are conceptual diagrams illustrating states that the arc-shaped caulking portions are coupled to each other.

FIGS. **23**A, **23**B, and **23**C are conceptual diagrams illustrating a procedure of manufacturing a laminated magnetic body in the laminated stator core shown in FIG. **18**.

FIGS. **24**A and **24**B are conceptual diagrams illustrating a procedure of manufacturing the laminated stator core shown in FIG. **18**.

FIGS. **25**A and **25**B are conceptual diagrams illustrating a procedure of manufacturing a laminated yoke body having different shapes of arc-shaped caulking portions and FIG. **25**C is a partial plan view illustrating an example of a band-shaped yoke core piece.

FIGS. **26**A and **26**B are a partial plan view and a partial cross-sectional view illustrating an arc-shaped caulking portion of a band-shaped yoke core piece.

FIGS. **27**A and **27**B are conceptual diagrams illustrating a state that the arc-shaped caulking portions are coupled to each other.

FIGS. **28**A and **28**B are a partial plan view and a partial cross-sectional view illustrating a modification of the arc-shaped caulking portion in the band-shaped yoke core piece.

FIGS. **29**A and **29**B are an entire plan view and an entire side view illustrating a laminated stator core manufactured by the use of a method according to an embodiment of the present invention.

FIGS. **30**A and **30**B are perspective views illustrating appearances of inner yoke-attachment laminated magnetic sub-bodies and an outer laminated yoke body constituting the laminated stator core shown in FIG. **29**.

FIGS. **31**A and **31**B are conceptual diagrams illustrating a procedure of manufacturing the outer laminated yoke body of the laminated stator core shown in FIG. **29**.

FIGS. **32**A and **32**B are a partial plan view and a partial cross-sectional view illustrating a caulking portion of a band-shaped yoke core sub-piece, respectively.

FIGS. **33**A, **33**B, and **33**C are conceptual diagrams illustrating a procedure of manufacturing the inner yoke-attachment laminated magnetic sub-body of the laminated stator core shown in FIG. **29**.

FIG. **34** is a conceptual diagram illustrating a procedure of manufacturing the laminated stator core shown in FIG. **29**.

FIG. **35** is a conceptual diagram illustrating a procedure of manufacturing the laminated stator core shown in FIG. **29**.

FIG. **36** is a conceptual diagram illustrating a procedure of manufacturing the laminated stator core shown in FIG. **29**.

FIGS. **37**A and **37**B are a perspective view illustrating another example of the inner yoke-attachment laminated magnetic sub-body and a plan view illustrating a state that a coil is wound thereon.

FIGS. **38**A, **38**B, and **38**C are plan views illustrating a procedure of forming inner yoke-attachment magnetic core sub-pieces constituting the inner yoke-attachment laminated magnetic sub-body and illustrating two kinds of inner yoke-attachment magnetic core sub-pieces.

FIGS. **39**A and **39**B are a partial plan view and a partial cross-sectional view of an intermediate assembly illustrating a coupling state of the inner yoke-attachment laminated magnetic sub-body shown in FIG. **37**, respectively.

FIGS. **40**A and **40**B are an entire plan view and an entire side view illustrating an example of a laminated stator core manufactured by the use of the method according to the present invention, respectively.

FIGS. **41**A and **41**B are perspective views illustrating appearances of an inner yoke-attachment laminated magnetic sub-body and an outer laminated yoke body constituting the laminated stator core shown in FIG. **40**.

FIGS. **42**A and **42**B are conceptual diagrams illustrating a procedure of manufacturing the outer laminated yoke body of the laminated stator core shown in FIG. **40**.

FIGS. **43**A and **43**B are a partial plan view and a partial cross-sectional view illustrating the caulking portion of a band-shaped yoke core sub-piece, respectively.

FIGS. **44**A and **44**B are conceptual diagrams illustrating a procedure of manufacturing the inner yoke-attachment laminated magnetic sub-body of the laminated stator core shown in FIG. **40**.

FIG. **45** is a conceptual diagram illustrating a manufacturing procedure according to the present invention.

FIG. **46** is a conceptual diagram illustrating a manufacturing procedure according to the present invention.

FIG. **47** is a conceptual diagram illustrating a manufacturing procedure according to the present invention.

FIG. **48** is a conceptual diagram illustrating a manufacturing procedure according to the present invention.

FIGS. **49**A and **49**B are a perspective view illustrating another example of the inner yoke-attachment laminated magnetic sub-body and a plan view illustrating a state that a coil is wound thereon, respectively.

FIGS. **50**A, **50**B, and **50**C are plan views illustrating a procedure of forming inner yoke-attachment magnetic core sub-pieces constituting the inner yoke-attachment laminated magnetic sub-body shown in FIG. **49** and illustrating two kinds of inner yoke-attachment magnetic core sub-pieces.

FIGS. **51**A and **51**B are a partial plan view and a partial cross-sectional view of an intermediate assembly illustrating a coupling state of the inner yoke-attachment laminated magnetic sub-body shown in FIG. **10**, respectively.

FIG. **52** is a perspective view illustrating an appearance of a laminated rotor core manufactured by the use of a method according to an embodiment of the present invention.

FIGS. **53**A and **53**B are conceptual diagrams illustrating a procedure of manufacturing the laminated rotor core shown in FIG. **52**.

FIG. **54** is a partial plan view illustrating a band-shaped core piece constituting the laminated rotor core shown in FIG. **52**.

FIGS. **55**A and **55**B are a partial plan view and a partial cross-sectional view illustrating a band-shaped core piece constituting the laminated rotor core shown in FIG. **52**, respectively.

FIGS. **56**A and **56**B are conceptual diagrams illustrating a procedure of manufacturing a rotor including the laminated rotor core shown in FIG. **52**.

FIG. **57** is a perspective view illustrating an appearance of the laminated rotor core manufactured by the use of a method according to another embodiment of the present invention.

FIGS. **58**A and **58**B are conceptual diagrams illustrating a procedure of manufacturing the laminated rotor core shown in FIG. **57**.

FIG. **59** is a partial plan view illustrating a band-shaped core piece constituting the laminated rotor core shown in FIG. **57**.

FIGS. **60**A and **60**B are a partial plan view and a partial cross-sectional view illustrating the band-shaped core piece constituting the laminated rotor core shown in FIG. **57**, respectively.

FIGS. **61**A and **61**B are conceptual diagrams illustrating a procedure of manufacturing a rotor having the laminated rotor core shown in FIG. **6** as an element.

FIGS. **62**A and **62**B are an entire plan view and a partial cross-sectional view illustrating a laminated stator core manufactured according to the related art, respectively.

FIG. **63** is a conceptual diagram illustrating a method of manufacturing the laminated stator core shown in FIG. **62**.

FIGS. **64**A, **64**B, and **64**C are conceptual diagrams illustrating a method of manufacturing another laminated stator core according to the related art.

FIGS. **65**A and **65**B are conceptual diagrams illustrating a method of manufacturing another laminated stator core according to the related art.

FIG. **66** is a perspective view illustrating an appearance of a laminated rotor core manufactured according to the related art.

FIGS. **67**A and **67**B are conceptual diagrams illustrating a procedure of manufacturing the laminated rotor core shown in FIG. **66**.

REFERENCE NUMERALS

1: LAMINATED STATOR CORE
10: LAMINATED YOKE BODY
11: BAND-SHAPED YOKE CORE PIECE
11*i*: INNER CIRCUMFERENTIAL EDGE
11*a*: CONCAVE CONNECTION PORTION
11*c*: CAULKING PORTION
10': LAMINATED YOKE BODY
11': BAND-SHAPED YOKE CORE PIECE
11*i*': INNER CIRCUMFERENTIAL EDGE
11*a*': CONCAVE CONNECTION PORTION
11*o*': INNER CIRCUMFERENTIAL EDGE
11*p*': THIN PORTION
11*c*': CAULKING PORTION
20: LAMINATED MAGNETIC BODY
21: MAGNETIC CORE PIECE
21*a*: CONVEX CONNECTION PORTION
21*c*: CAULKING PORTION
21': MAGNETIC CORE PIECE
21*a*': CONVEX CONNECTION PORTION
21*c*': CAULKING PORTION
21*t*': TAPERED PORTION
21": MAGNETIC CORE PIECE
21*a*": CONVEX CONNECTION PORTION
21*c*": CAULKING PORTION
21*p*": MINUTE PROTRUSION
L: WINDING
W: BAND-SHAPED STEEL PLATE (METAL PLATE)

BEST MODE FOR CARRYING OUT THE INVENTION

Hereinafter, the present invention will be described in detail with reference to the drawings illustrating embodiments thereof.

First Embodiment

FIGS. **1** to **7** illustrate a method of manufacturing a laminated stator core according to the present invention. The laminated stator core **1** manufactured according to the present invention includes a laminated yoke body **10** having a band shape and a predetermined number of laminated magnetic bodies **20**, **20**, . . . (twelve in the first embodiment) coupled to the inner circumferential edge of the laminated yoke body **10**.

As described later, the laminated yoke body **10** is constructed by winding and laminating a band-shaped yoke core piece **11**, which is formed by punching a band-shaped steel plate (metal plate), in a spiral shape and coupling the laminated band-shaped steel plate in a caulking manner (caulking lamination). A predetermined number of concave connection portions **11***a*, **11***a*, . . . (twelve in the first embodiment) are formed in the inner circumferential edge of the laminated yoke body **10**. Reference numeral **11***c* in the figures denotes a caulking portion formed in the band-shaped yoke core piece **11**.

On the other hand, the laminated magnetic body **20** is constructed by laminating a predetermined number of magnetic core pieces **21**, **21**, . . . , which is formed by punching a band-shaped steel plate (metal plate), and coupling them to each other in a caulking manner (caulking lamination) as described later. A convex connection portion **21***a* engaging with the concave connection portion **11***a* of the laminated yoke body **10** is formed at a base end of each laminated magnetic body **20**. Reference numeral **21***c* in the figures denotes a caulking portion formed in the respective magnetic core pieces **21**, **21**, ...

By inserting the convex connection portions **21***a* of the laminated magnetic bodies **20** into the concave connection portions **11***a*, **11***a*, . . . of the laminated yoke body **10** and coupling the laminated yoke body **10** and the laminated magnetic bodies **20**, **20**, . . . to each other, the laminated stator core **1** having a predetermined shape is manufactured in which a predetermined number of laminated magnetic bodies **20**, **20**, . . . are protruded in the inner radius direction of the laminated yoke body **10**.

A method of manufacturing the laminated stator core according to the present invention is now described in detail by exemplifying a procedure of manufacturing the laminated stator core **1**.

First, as shown in FIG. **3**A, the band-shaped yoke core pieces **11** are formed by punching an electromagnetic steel plate (metal plate) not shown.

The band-shaped yoke core pieces **11** have a shape that the yoke of the laminated stator core **1** is developed in a straight line, specifically, a band shape straightly extending and having a small width. Caulking portions **11***c*, **11***c*, . . . are arranged with a predetermined pitch at the central area thereof.

Concave connection portions **11***a*, **11***a*, . . . are arranged with a predetermined pitch at the inner circumferential edge **11***i* of the band-shaped yoke core pieces **11**, that is, at a portion constituting the inner circumferential surface of the laminated yoke body **10** (see FIG. **2**) when the band-shaped yoke core piece **11** is wound in the subsequent process.

Here, the pitch of the concave connection portions **11***a*, **11***a*, . . . is set so that the concave connection portions **11***a* overlap with each other when the band-shaped yoke core piece **11** is wound and laminated in a spiral shape in the subsequent process. Similarly, the pitch of the caulking portions **11***c*, **1***c*, . . . is set so that the caulking portions **11***c* overlap with each other when the band-shaped yoke core piece **11** is wound and laminated in a spiral shape in the subsequent process.

After forming the band-shaped yoke core piece **11** by punching the electromagnetic steel plate (metal plate), the band-shaped yoke core piece **11** is taken into a manufacturing apparatus (not shown). Then, as shown in FIG. **3**B, the laminated yoke body **10** (see FIG. **2**B) is formed by winding and laminating the band-shaped yoke core piece **11** in a spiral shape and coupling the laminated band-shaped yoke core piece in a caulking manner.

Specifically, the laminated yoke body **10** is manufactured, as shown in FIG. **2**B, by suspending one end of the band-shaped yoke core piece **11** on a winding guide G of the manufacturing apparatus, winding the band-shaped yoke core piece **11** around the winding guide G rotating in the arrow direction R while taking the band-shaped yoke core piece **11** into the winding guide G as indicated by the arrow F, and coupling the band-shaped yoke core piece **11** laminated in a predetermined number of layers by the use of the caulking portions **11***c*, **11***c*, . . . in a caulking manner.

Here, since the band-shaped yoke core piece **11** constituting the laminated yoke body **10** has a band shape with a small width as described above and the concave connection portions **11***a*, **11***a*, . . . are formed in the inner circumferential edge **11***i* thereof, bending processability thereof is very excellent. Accordingly, it is possible to form the laminated yoke body **10**, in which the band-shaped yoke core piece **11** is wound, in a circular shape.

After forming the laminated yoke body **10** (see FIG. **2**B) with a manufacturing apparatus (not shown), the shape of the laminated yoke body **10** is corrected by inserting a correcting tool (not shown) into the central opening of the laminated yoke body **10** and applying a diameter enlarging force Q, Q, . . . to the laminate yoke body **10** from the inner circumference as shown in FIG. **4**.

In this way, by correcting the shape, it is possible to improve the degree of circularity of the laminated yoke body **10** and thus to manufacture the laminated stator core **1** excellent in shaping precision.

On the other hand, as shown in FIG. **5**A, the laminated magnetic body **20** is formed out of an electromagnetic steel plate (metal plate) W by the use of machining stations S**1** to S**3** of a transfer press (not shown).

That is, pilot holes P are formed by the use of the machining station S**1**, caulking portions **21***c* are formed by the use of the machining station S**2**, and the laminated magnetic body **20** (see FIG. **5**B) is manufactured by performing a blanking/caulking process to the magnetic core pieces **21** by the use of the machining station S**3**.

The procedure of manufacturing the laminated magnetic body **20** using the transfer press is not limited to the above-mentioned embodiment, but may be established properly.

Here, since each laminated magnetic body **20** is formed by laminating the magnetic core pieces **21**, **21**, . . . as described above, the laminated magnetic body is manufactured without departure between the laminated magnetic core pieces **21**. Accordingly, the laminated stator core **1** in which the laminated magnetic bodies **20** are coupled to the laminated yoke body **10** has excellent shaping precision.

Since the laminated magnetic bodies **20** are formed independently of the laminated yoke body **10**, the yield of forming the magnetic core pieces **21**, **21**, . . . out of an electromagnetic steel plate (metal plate) W is enhanced. Therefore, it is possible to prevent increase in manufacturing cost.

After manufacturing the laminated magnetic bodies **20** as described above, coils L are wound around the laminated magnetic bodies **20** by the use of a specific apparatus (not shown) as shown in FIG. **5**C. As well as directly winding the coils L around the laminated magnetic bodies **20**, a bobbin (not shown) on which the coils L are wound may be mounted on the laminated magnetic bodies **20** in an additional process.

Here, since the laminated magnetic bodies **20** are separated from the laminated yoke body **10** at the time of winding the coils L around the laminated magnetic bodies **20**, the winding work of the coils L around the laminated magnetic bodies **20** is very easy. Accordingly, it is possible to wind the coils L with a high density and an excellent proportion.

After winding coils L around the predetermined number of laminated magnetic bodies **20**, the laminated magnetic bodies **20** are coupled and fixed to the laminated yoke body **10** by inserting the convex connection portions **21***a* of the laminated magnetic bodies **20** into the concave connection portions **10***a* of the laminated yoke body **10** in the axial direction of the laminated yoke body **10**.

As described above, by inserting the convex connection portions **21***a* of the laminated magnetic bodies **20** into the concave connection portions **11***a* of the laminated yoke body **10** and coupling and fixing the laminated yoke body **10** and the laminated magnetic bodies **20** to each other, the laminated stator core **1** having a predetermined shape is manufactured and a stator of an electric motor is completed in which the coils L are wound around the laminated magnetic bodies **20**, **20**, . . . of the laminated stator core **1**.

The concave connection portion **11***a* of the laminate yoke body **10** has a rectangular shape as shown in FIG. **7**A before winding the band-shaped yoke core piece **11**. However, since the width of the opening is decreased toward the inner circumference as shown in FIG. **7**B after winding the band-shaped yoke core piece **11** and forming the laminated yoke body **10**, the convex connection portion **21***a* of the laminated magnetic body **20** is tightly inserted into the concave connection portion **11***a*. Accordingly, the laminated yoke body **10** and the laminated magnetic body **20** are strongly coupled to each other.

As described above, by the use of the method of manufacturing a laminated stator core according to the first embodiment, it is possible to manufacture a laminated stator core excellent in shaping precision and electrical characteristic.

FIG. **8** shows another example of a laminated stator core manufactured by the use of the method according to the present invention. In the laminated stator core **1**, the laminated magnetic body **20** is connected to the laminated yoke body **10** by inserting the convex connection portion **21***a* of the laminated magnetic body **20** into the concave connection portion **11***a* of the laminated yoke body **10** and fixing engagement portions **30**, **30**, . . . are formed around the concave connection portion **11***a* by pressing.

The fixing engagement portions **30** formed by pressing minutely deform the periphery of the concave connection portion **11***a* to tighten the corresponding convex connection portion **21***a* of the laminated magnetic body **20**. Accordingly, the laminated yoke body **10** and the laminated magnetic body **20** are strongly connected to each other.

Here, the structure of the laminated stator core **1** described above is similar to that of the laminated stator core **1** shown in FIGS. **1** to **7**, except that the fixing engagement portions **30**, **30**, . . . are formed by pressing around the concave connection portion **11***a*. In FIG. **8**, the coil L (see FIG. **6**) wound on each laminated magnetic body **20** is omitted.

According to the above-mentioned method of manufacturing a laminated stator core, it is possible to manufacture a laminated stator core **1** with largely enhanced the coupling strength between the laminated yoke body **10** and the laminated magnetic body **20** by forming the fixing engagement portions **30**, **30**, . . . around the concave connection portion **11***a*.

The portions in which the fixing engagement portions **30**, **30**, . . . are formed by pressing is not limited to the periphery of the concave connection portion **11***a* as described above, but the fixing engagement portions may be formed by pressing in the circumferential edge of the convex connection portion **21***a* of the laminated magnetic body **20** or in both of the periphery of the concave connection portion **11***a* and the circumferential edge of the convex connection portion **21***a*.

FIG. **9** shows other examples of the laminated stator core manufactured according to the first embodiment. In the laminated magnetic body **20'** shown in FIG. **9**A, tapered portions **21***t*', **21***t*' are formed on the lateral surfaces of the convex connection portion **21***a*' and thus the convex connection portion **21***a*' has a tapered (reversely tapered) shape widened toward the end. In the laminated magnetic body **20"** shown in FIG. **9**B, minute protrusions **21***p*", **21***p*", . . . are formed on the lateral surfaces of the convex connection portion **21***a*".

The laminated magnetic body **20'** is strongly connected to the laminated yoke body **10** by inserting the convex connection portion **21***a*' of the laminated magnetic body **20'** into the concave connection portion **11***a* of the laminated yoke body **10**. Similarly, the laminated magnetic body **20"** is strongly connected to the laminated yoke body **10** by inserting the convex connection portion **21***a*" of the laminated magnetic body **20"** into the concave connection portion **11***a* of the laminated yoke body **10**.

Second Embodiment

FIGS. **10** and **11** show a method of manufacturing a laminated stator core according to a second embodiment of the present invention.

The method according to the second embodiment is basically similar to the method according to the first embodiment described with reference to FIGS. **1** to **9**, except that the details of the processes of forming a laminated yoke body **10'** are different as described later. The laminated stator core manufactured according to the first embodiment is basically similar to the laminated stator core **1** shown in FIGS. **1** to **9**, except that a partial shape of the laminated yoke body **10'** is different.

In the method of manufacturing a laminated stator core according to the second embodiment, first, as shown in FIG. **10**A, a band-shaped yoke core piece **11'** is formed by punching an electromagnetic steel plate (metal plate) not shown.

The band-shaped yoke core piece **11'** has a shape that the yoke of the laminated stator core as a complete product is developed in a straight line, that is, a band shape extending straightly with a small width. Caulking portions **11***c*', **11***c*', . . . are arranged in the central area thereof.

The concave connection portions **11***a*', **11***a*', . . . are arranged with a predetermined pitch in the inner circumferential edge **11***i*' of the band-shaped yoke core piece **11'**, that is, in the portions constituting the inner circumferential surface of the laminated yoke body **10'** (see FIG. **11**B) when the band-shaped yoke core piece **11'** is wound in the subsequent process. The shape of the band-shaped yoke core piece **11'** is similar to that of the band-shaped yoke core piece **11** described with reference to FIG. **1**.

After forming the band-shaped yoke core piece **11'** by punching the electromagnetic steel plate (metal plate), the band-shaped yoke core piece **11'** is taken into a manufacturing apparatus (not shown). Then, as shown in FIG. **10**B, the laminated yoke body **10'** (see FIG. **11**B) is formed by locally pressing the outer circumferential edge **11***o*' of the band-shaped yoke core piece **11'** to roll the band-shaped yoke core piece in a longitudinal direction, winding and laminating the band-shaped yoke core piece **11'** in a spiral shape, and coupling the laminated band-shaped yoke core piece in a caulking manner.

Specifically, the band-shaped yoke core piece **11'** is bent by suspending one end of the band-shaped yoke core piece **11'** on a winding guide G of the manufacturing apparatus and winding the band-shaped yoke core piece **11'** on the winding guide G rotating in the arrow direction R while taking the band-shaped yoke core piece **11'** into the winding guide G in the arrow direction F.

At this time, before bending the band-shaped yoke core piece **11'** by winding the band-shaped yoke core piece on the winding guide G, the outer circumferential edge **11***o'* is locally pressed to roll the band-shaped yoke core piece by forming by pressing thin portions **11***p'* in the outer circumferential edge **11***o'* of the band-shaped yoke core piece **11'**, as shown in FIG. **10**B. The thin portions **11***p'* are formed with a predetermined pitch in the outer circumferential edge **11***o'* with movement of the band-shaped yoke core piece **11'**.

As described above, after forming the thin portions **11***p'* in the outer circumferential edge **11***o'* of the band-shaped yoke core piece **11'**, the laminated yoke body **10'** having a predetermined shape is manufactured as shown in FIG. **11**B by winding the band-shaped yoke core piece **11'** on the winding guide G rotating and coupling the band-shaped yoke core piece **11'** laminated in a predetermined number of layers by the caulking portions **11***c'*, **11***c'*, . . . in a caulking manner.

Here, since the band-shaped yoke core piece **11'** constituting the laminated yoke body **10'** has a band shape with a small width as described above and the concave connection portions **11***a'*, **11***a'*, . . . are formed in the inner circumferential edge **11***i'* thereof, bending processability thereof is very excellent. Accordingly, it is possible to form the laminated yoke body **10'**, in which the band-shaped yoke core piece **11'** is wound, in a circular shape.

By locally pressing the outer circumferential edge **11***o'* of the band-shaped yoke core piece **11'** to roll the band-shaped yoke core piece in a longitudinal direction before winding the band-shaped yoke core piece **11'** in a spiral shape, it is possible to easily wind the band-shaped yoke core piece **11' 10'**. Accordingly, the degree of circularity of the laminated yoke body formed by winding the band-shaped yoke core piece **11'** is enhanced and thus the shaping precision of the laminated yoke body **10'** is enhanced.

Since the thin portions **11***p'* formed by local pressing exist not continuously but locally (intermittently), the appearance of the laminated stator core is not deteriorated. In addition, since dust or the like does not invade the laminated stator core, it is possible to elongate a lifetime the laminated stator core.

Similarly to the method of manufacturing a laminated stator core according to the first embodiment, by connecting a laminated magnetic body (not shown) formed separately to the laminated yoke body **10'** formed as described above, the laminated stator core having a predetermined shape is manufactured.

In this way, by the use of the method of manufacturing a laminated stator core according to the second embodiment, it is possible to manufacture a laminated stator core excellent in shaping precision and electrical characteristic, similarly to the method of manufacturing a laminated stator core according to the first embodiment.

In the above-mentioned embodiments, the laminated stator core including the laminated yoke body having a ring shape and the twelve laminated magnetic bodies is exemplified. However, the present invention is not limited to the manufacturing the above-mentioned laminated stator core, but may apply effectively to methods of manufacturing laminated stator cores having various structures.

Third Embodiment

FIGS. **12** to **17** show a method of manufacturing a laminated stator core according to a third embodiment of the present invention. The laminated stator core **1** manufactured according to the third embodiment includes a laminated yoke body **10** having a ring shape and a predetermined number (twelve in the third embodiment) of laminated magnetic bodies **20**, **20**, . . . coupled to the inner circumference of the laminate yoke body **10**.

The laminated yoke body **10** is constructed by winding and laminating the band-shaped yoke core piece **11**, which is formed by punching a band-shaped steel plate (metal plate), in a spiral shape and coupling them in a caulking manner (caulking lamination) as described later. A predetermined number (twelve in the third embodiment) of concave connection portions **11***a*, **11***a*, . . . are formed in the inner circumferential edge of the laminated yoke body **10**. Reference Numeral **11***c* in the figures denotes the caulking portions formed in the band-shaped yoke core piece **11**.

On the other hand, the laminated body **20** is constructed as described later by laminating a predetermined number of magnetic core pieces **21**, **21**, . . . formed by punching a band-shaped steel plate (metal plate) and coupling the laminated magnetic core pieces to each other in a caulking manner. Convex connection portions **21***a* engaging with the concave connection portions **11***a* of the laminated yoke body **10** are formed in the base ends. Reference numeral **21***c* in the figure denotes caulking portions formed in the magnetic core pieces **21**, **21**, ...

By inserting the convex connection portions **21***a* of the laminated magnetic bodies **20** into the concave connection portions **11***a*, **11***a*, . . . of the laminated yoke body **10** and coupling the laminated yoke body **10** and the laminated magnetic bodies **20**, **20**, . . . to each other, the laminated stator core **1** having a predetermined shape is manufactured in which a predetermined number of laminated magnetic bodies **20**, **20**, . . . are protruded in the inner radius direction of the laminated yoke body **10**.

Now, a method of manufacturing a laminated stator core according to the present invention will be described in detail by exemplifying a procedure of manufacturing the laminated stator core **1**.

First, as shown in FIG. **14**A, the band-shaped yoke core piece **11** is formed by punching an electromagnetic steel plate (metal plate) not shown.

The band-shaped yoke core piece **11** has a shape that the yoke of the laminated stator core **1** is developed in a straight line, that is, a band shape extending straightly with a small width. The caulking portions **11***c*, **11***c*, . . . are arranged with a predetermined pitch at the central area thereof.

Concave connection portions **11***a*, **11***a*, . . . are arranged with a predetermined pitch in the inner circumference edge **11***i* of the band-shaped yoke core piece **11**, that is, in the portions constituting the inner circumferential surface of the laminated yoke body **10** (see FIG. **13**) when the band-shaped yoke core piece **11** is wound in the subsequent process.

Here, the pitch of the concave connection portions **11***a*, **11***a*, . . . is set so that the concave connection portions **11***a* are overlapped with each other when the band-shaped yoke core piece **11** is wound in a spiral shape in the subsequent process. Similarly, the pitch of the caulking portions **11***c*, **11***c*, . . . is set so that the caulking portions **11***c* are overlapped with each other when the band-shaped yoke core piece **11** is wound in a spiral shape in the subsequent process.

After forming the band-shaped yoke core piece **11** by punching the electromagnetic steel plate (metal plate), the band-shaped yoke core piece **11** is taken into a manufacturing apparatus (not shown). Then, as shown in FIG. **14**B, the laminated yoke body **10** (see FIG. **13**B) is formed by winding and laminating the band-shaped yoke core piece **11** in a spiral shape and coupling the laminated band-shaped yoke core piece in a caulking manner.

Specifically, the laminated yoke body **10** having a predetermined shape is manufactured, as shown in FIG. **13**B, by suspending one end of the band-shaped yoke core piece **11** on a winding guide G of the manufacturing apparatus, winding the band-shaped yoke core piece **11** around the winding guide G rotating in the arrow direction R while taking the band-shaped yoke core piece **11** into the winding guide G in the arrow direction F, coupling the laminated band-shaped yoke core piece **11** by the use of the caulking portions **11***c*, **11***c*, . . . in a caulking manner, and locally pressing the periphery of the caulking portions **11***c* including the caulking portions **11***c*. The laminated yoke body can be also manufactured by coupling the laminated band-shaped yoke core piece **11** by the use of the caulking portions **11***c*, **11***c*, . . . in a caulking manner and locally pressing the caulking portions **11***c*.

Here, since the band-shaped yoke core piece **11** constituting the laminated yoke body **10** has a band shape with a small width as described above and the concave connection portions **11***a*, **11***a*, . . . are formed in the inner circumferential edge **11***i* thereof, bending processability thereof is very excellent. Accordingly, it is possible to form the laminated yoke body **10**, in which the band-shaped yoke core piece **11** is wound, in a circular shape.

In the third embodiment, the inner portion of the concave connection portion **11***a* is formed in a substantially rectangular shape. However, for example, as shown in FIG. **14**C, by forming the inner edge in a curved line and connecting the inner edge and the lateral edges with a curved line to form the inner edges of the concave connection portion **11***a* into a continuous round shape, it is possible to further enhance the bending processability (winding formability).

When coupling the band-shaped yoke core piece **11** in a caulking manner, as shown in FIGS. **14** and **15**, the laminated band-shaped yoke core piece **11** comes in close contact with each other by forming pressed portions **11***p* in the peripheries of the caulking portions including the caulking portions **11***c* through the local pressing, thereby preventing generation of a gap. Accordingly, the laminated yoke body **10** having a large coupling strength is obtained. In addition, by locally pressing the caulking portions **11***c*, the laminated yoke body having a large coupling strength can be obtained as described above.

As shown in FIGS. **14** and **15**, since the pressed portions **11***p* are formed by press in the area widened from the caulking portions **11***c* toward the outer circumferential edge **11***o* of the band-shaped yoke core piece **11**, it is possible to easily wind the band-shaped yoke core piece **11** by stretching the area outside the caulking portions **11***c* in the band-shaped yoke core piece **11**. Accordingly, the degree of circularity of the laminated yoke body **10** formed by winding the band-shaped yoke core piece **11** is enhanced and the shaping precision of the laminated yoke body **10** is very excellent.

On the other hand, as shown in FIG. **16**A, the laminated magnetic body **20** is formed out of an electromagnetic steel plate (metal plate) W by the use of machining stations S**1** to S**3** of a transfer press (not shown).

That is, pilot holes P are formed by the use of the machining station S**1**, caulking portions **21***c* are formed by the use of the machining station S**2**, and the laminated magnetic body **20** (see FIG. **16**B) is manufactured by performing a blanking/caulking process to the magnetic core pieces **21** by the use of the machining station S**3**.

The procedure of manufacturing the laminated magnetic body **20** by the use of the transfer press is not limited to the above-mentioned embodiment, but may be established properly.

Here, since each laminated magnetic body **20** is formed by laminating a predetermined number of magnetic core pieces **21**, **21**, . . . in a caulking manner as described above, the laminated magnetic body is manufactured without departure between the laminated magnetic core pieces **21**. Accordingly, the laminated stator core **1** in which the laminated magnetic bodies **20** are coupled to the laminated yoke body **10** has very excellent shaping precision.

Since the laminated magnetic bodies **20** are formed independently of the laminated yoke body **10**, the yield of forming the magnetic core pieces **21**, **21**, . . . out of an electromagnetic steel plate (metal plate) W is enhanced. Therefore, it is possible to prevent increase in manufacturing cost.

After manufacturing the laminated magnetic bodies **20** as described above, coils L are wound around the laminated magnetic bodies **20** by the use of a specific apparatus (not shown) as shown in FIG. **16**C. As well as directly winding the coils L around the laminated magnetic bodies **20**, a bobbin (not shown) on which the coils L are wound may be mounted on the laminated magnetic bodies **20** in an additional process.

Here, since the laminated magnetic bodies **20** are separated from the laminated yoke body **10** at the time of winding the coils L on the laminated magnetic bodies **20**, the winding work of the coils L on the laminated magnetic bodies **20** is very easy. Accordingly, it is possible to wind the coils L with a high density and an excellent proportion.

After completing the winding of the coils L on a predetermined number of laminated magnetic bodies **20**, the laminated magnetic bodies **20** are coupled to the laminated core body **10** by inserting the convex connection portions **21***a* of the laminated magnetic bodies **20** into the concave connection portions **10***a* of the laminated yoke body **10** along the diameter direction of the laminated yoke body **10**.

As described above, by inserting the convex connection portions **21***a* of the laminated magnetic bodies **20** into the concave connection portions **11***a* of the laminated yoke body **10** and coupling the laminated yoke body **10** and the laminated magnetic bodies **20** to each other, the laminated stator core **1** having a predetermined shape is manufactured and a stator of an electric motor is completed in which the coils L are wound on the laminated magnetic bodies **20**, **20**, . . . of the laminated stator core **1**.

As described above, by the use of the method of manufacturing a laminated stator core according to the present invention, it is possible to manufacture a laminated stator core **1** excellent in shaping precision, mechanical strength, and electrical characteristic.

In the above-mentioned embodiment, the laminated stator core including the laminated yoke body having a ring shape and the twelve laminated magnetic bodies is exemplified. However, the present invention is not limited to the manufacturing the above-mentioned laminated stator core, but may apply effectively to methods of manufacturing laminated stator cores having various structures.

Fourth Embodiment

FIGS. **18** to **24** show a method of manufacturing a laminated stator core according to a fourth embodiment of the present invention. The laminated stator core **1** manufactured according to the fourth embodiment includes a laminated yoke body **10** having a ring shape and a predetermined number (twelve in the third embodiment) of laminated magnetic bodies **20**, **20**, . . . coupled to the inner circumference of the laminate yoke body **10**.

The laminated yoke body **10** is constructed by winding and laminating the band-shaped yoke core piece **11**, which is formed by punching a band-shaped steel plate (metal plate), in a spiral shape and coupling them in a caulking manner (caulking lamination) as described later. A predetermined number (twelve in the third embodiment) of concave connection portions **11***a*, **11***a*, . . . are formed in the inner circumferential edge of the laminated yoke body **10**.

Arc-shaped caulking portions **11***c*, **11***c*, . . . having a structure to be described in detail later are formed in the band-shaped yoke core piece **11** and the laminated band-shaped yoke core piece **11** is coupled by the use of the arc-shaped caulking portions **11***e* in a caulking manner.

On the other hand, the laminated magnetic body **20** is formed by laminating a predetermined number of magnetic core pieces **21**, **21**, . . . , which are formed by punching a band-shaped steel plate (metal plate) as described later, and coupling the laminated magnetic core pieces to each other in a caulking manner. Convex connection portions **21***a* engaging with the concave connection portions **11***a* of the laminated yoke body **10** are formed in the base end of the respective laminated magnetic bodies **20**. Reference numeral **21***c* in the figures denotes the caulking portions formed in the respective magnetic core pieces **21**, **21**, ...

The magnetic core pieces **21**, **21**, . . . constituting the laminated magnetic body **20** are made of a material having a iron loss lower than that of the band-shaped yoke core piece **11** constituting the laminated yoke body **10**, specifically, a material such as a thin electromagnetic steel plate and a thin amorphous metal plate having an iron loss lower than the iron loss of the electromagnetic steel plate when the band-shaped yoke core piece **11** is made of the electromagnetic steel plate.

By inserting the convex connection portions **21***a* of the laminated magnetic bodies **20** into the concave connection portions **11***a*, **11***a*, . . . of the laminated yoke body **10** and coupling the laminated yoke body **10** and the laminated magnetic bodies **20**, **20**, . . . to each other, the laminated stator core **1** having a predetermined shape is manufactured in which a predetermined number of laminated magnetic bodies **20**, **20**, . . . are protruded in the inner radius direction of the laminated yoke body **10**.

A method of manufacturing the laminated stator core according to the present invention will be now described in detail by exemplifying a procedure of manufacturing the laminated stator core **1**.

First, as shown in FIG. **21**A, the band-shaped yoke core pieces **11** are formed by punching a band-shaped steel plate (metal plate) not shown.

The band-shaped yoke core pieces **11** have a shape that the yoke of the laminated stator core **1** is developed in a straight line, that is, a band shape extending straightly with a small width. Concave connection portions **11***a*, **11***a*, . . . are arranged with a predetermined pitch in the inner circumferential edge **11***i*, that is, in a portion constituting the inner circumference of the laminated yoke body **10** (see FIG. **19**) when the band-shaped yoke core pieces **11** are wound in the subsequent process.

The pitch of the concave connection portions **11***a*, **11***a*, . . . is set so that the concave connection portions **11***a* are overlapped with each other when the band-shaped yoke core pieces **11** are wound and laminated in a spiral shape in the subsequent process.

Arc-shaped caulking portions **11***c*, **11***c*, . . . are arranged with a predetermined pitch in the central area in the width direction of the band-shaped yoke core pieces **11**.

As shown in FIG. **21**, each arc-shaped caulking portion **11***c* has a caulking tongue **11***t* protruded downwardly by means of a half blanking and a caulking groove **11***r* formed at the back side of the caulking tongue **11***t*.

The arc-shaped caulking portions **11***c* (including the caulking tongue **11***t* and the caulking groove **11***r*) have a plane shape curved in the winding direction (arrow direction R), that is, in the direction in which the band-shaped yoke core pieces **11** are wound in the subsequent process, more specifically, in the circumference direction in which the arc-shaped caulking portions **11***c*, **11***c*, . . . are arranged in the completed laminated yoke body **10** (see FIGS. **18** and **19**).

As shown in FIG. **21**, in the arc-shaped caulking portions **11***c*, caulking tongues **11***t* are downwardly tilted in the direction opposite to the winding direction (arrow direction F) when the band-shaped yoke core piece **11** is wound in the subsequent process.

Here, the pitch of the arc-shaped caulking portions **11***c*, **11***c*, . . . is set so that the arc-shaped caulking portions **11***c* are overlapped with each other when the band-shaped yoke core piece **11** is wound in a spiral shape in the subsequent process.

After forming the band-shaped yoke core piece **11** by punching the band-shaped steel plate (metal plate), the band-shaped yoke core piece **11** is taken into a manufacturing apparatus (not shown). Then, as shown in FIG. **20**B, the laminated yoke body **10** having a predetermined shape (see FIG. **19**B) is formed by winding and laminating the band-shaped yoke core piece **11** in a spiral shape and coupling the laminated band-shaped yoke core piece by the use of the arc-shaped caulking portions **11***c*, **11***c*, . . . in a caulking manner.

Specifically, the laminated yoke body **10** is manufactured, as shown in FIG. **19**B, by suspending one end of the band-shaped yoke core piece **11** on a winding guide G of the manufacturing apparatus, winding the band-shaped yoke core piece **11** around the winding guide G rotating in the arrow direction R while taking the band-shaped yoke core piece **11** into the winding guide G in the arrow direction F, and coupling the laminated band-shaped yoke core piece **11** by the use of the caulking portions **11***c*, **11***c*, . . . in a caulking manner.

Here, since the band-shaped yoke core piece **11** constituting the laminated yoke body **10** has a band shape with a small width as described above and the concave connection portions **11***a*, **11***a*, . . . are formed in the inner circumferential edge **11***i* thereof, bending processability thereof is very excellent. Accordingly, it is possible to form the laminated yoke body **10**, in which the band-shaped yoke core piece **11** is wound, in a circular shape.

As shown in FIG. **20**C, by forming the inner edge of the concave connection portion **11***a* of the band-shaped yoke core piece **11** into a curved line and connecting the inner edge to the lateral edges with a curved line to form the edges into a continuous round shape, it is possible to further enhance the bending processability (winding formability).

By arranging the arc-shaped caulking portions **11***c* formed in the band-shaped yoke core piece **11** in a plane shape curved in the winding direction (arrow direction R), the caulking tongues **11***t* of the arc-shaped caulking portions **11***c* in an upper layer are inserted into the caulking grooves **11***r* of the arc-shaped caulking portions **11***c* in a lower layer so as to induce the winding of the band-shaped yoke core piece **11** at the time of winding and laminating the band-shaped yoke core piece **11** in a spiral shape. Accordingly, the shaping property of the band-shaped yoke core piece **11** at the time of winding is enhanced and it is thus possible to form the laminated yoke body **10** in a circular shape.

The caulking tongues **11***t* of the arc-shaped caulking portions **11***c* are tilted downwardly in the direction opposite to the winding direction (arrow direction F) of the band-shaped yoke core piece **11**. Accordingly, when the band-shaped yoke core piece **11** is wound in a spiral shape and laminated in a caulking manner, as shown in FIGS. **22**A and **22**B, the caulking tongues **11***t* in an upper layer are slowly inserted into the caulking grooves **11***r* in a lower layer from the base end to the front end and the entire caulking tongues **11***t* are completely inserted into the caulking grooves **11***r*. As a result, it is possible to form the laminated yoke body **10** having a large coupling strength.

On the other hand, as shown in FIG. **23**A, the laminated magnetic body **20** is formed out of a band-shaped steel plate (metal plate) W by the use of machining stations S**1** to S**3** of a transfer press (not shown).

That is, pilot holes P are formed by the use of the machining station S**1**, caulking portions **21***c* are formed by the use of the machining station S**2**, and the laminated magnetic body **20** (see FIG. **23**B) is manufactured by performing a blanking/caulking process to the magnetic core pieces **21** by the use of the machining station S**3**.

The procedure of manufacturing the laminated magnetic body **20** by the use of the transfer press is not limited to the above-mentioned embodiment, but may be established properly.

Here, since each laminated magnetic body **20** is formed by laminating the magnetic core pieces **21**, **21**, . . . in a caulking manner as described above, the laminated magnetic body **20** is manufactured without departure between the laminated magnetic core pieces **21**. Accordingly, the laminated stator core **1** in which the laminated magnetic bodies **20** are coupled to the laminated yoke body **10** has very excellent shaping precision.

Since the laminated magnetic bodies **20** are formed independently of the laminated yoke body **10**, the yield of forming the magnetic core pieces **21**, **21**, . . . out of an electromagnetic steel plate (metal plate) W is enhanced. Therefore, it is possible to prevent increase in manufacturing cost.

By making the magnetic core pieces **21**, **21**, . . . constituting the laminated magnetic body **20** out of a material having an iron loss smaller than that of the band-shaped yoke core pieces **11** constituting the laminated yoke body **10**, it is possible to accomplish more increase in efficiency and more save of energy of the laminated stator core **1** in which the laminated magnetic bodies **20**, **20**, . . . are coupled to the laminated yoke body **10**.

After manufacturing the laminated magnetic bodies **20** as described above, coils L are wound around the laminated magnetic bodies **20** by the use of a specific apparatus (not shown) as shown in FIG. **23**C. As well as directly winding the coils L around the laminated magnetic bodies **20**, a bobbin (not shown) on which the coils L are wound may be mounted on the laminated magnetic bodies **20** in an additional process.

Here, since the laminated magnetic bodies **20** are separated from the laminated yoke body **10** at the time of winding the coils L around the laminated magnetic bodies **20**, the winding work of the coils L around the laminated magnetic bodies **20** is very easy. Accordingly, it is possible to wind the coils L with a high density and an excellent proportion.

After completing the winding of the coils L on a predetermined number of laminated magnetic bodies **20**, the laminated magnetic bodies **20** are coupled to the laminated core body **10** by inserting the convex connection portions **21***a* of the laminated magnetic bodies **20** into the concave connection portions **11***a* of the laminated yoke body **10** along the diameter direction of the laminated yoke body **10**, as shown in FIGS. **24**A and **24**B.

As described above, by inserting the convex connection portions **21***a* of the laminated magnetic bodies **20** into the concave connection portions **11***a* of the laminated yoke body **10** and coupling the laminated yoke body **10** and the laminated magnetic bodies **20** to each other, the laminated stator core **1** having a predetermined shape is manufactured and a stator of an electric motor is completed in which the coils L are wound on the laminated magnetic bodies **20**, **20**, . . . of the laminated stator core **1**.

In this way, by the use of the method of manufacturing a laminated stator core according to the present invention, it is possible to manufacture a laminated stator core **1** excellent in shaping precision and electrical characteristic.

Fifth Embodiment

FIGS. **26** to **28** show another example of the band-shaped yoke core piece **11**, wherein arc-shaped caulking portions **11***c*', **11***c*', . . . are arranged with a predetermined pitch in the central area in the width direction of the band-shaped yoke core piece **11**.

As shown in FIG. **26**, each arc-shaped caulking portion **11***c*' has a caulking tongue **11***t*' protruded downwardly by means of a half blanking and a caulking groove formed at the back side of the caulking tongue **11***t*.

The arc-shaped caulking portion **11***c*' (including the caulking tongue **11***t*' and the caulking groove **11***r*') has a plane shape curved in the winding direction (arrow direction R), that is, in the direction in which the band-shaped yoke core pieces **11** are wound in the subsequent process.

As shown in FIG. **26**, in the arc-shaped caulking portions **11***c*', caulking tongues **11***t*' are downwardly tilted in the direction opposite to the winding direction (arrow direction F) when the band-shaped yoke core piece **11'** is wound in the subsequent process.

Here, the pitch of the arc-shaped caulking portions **11***c*', **11***c*', . . . is set so that the arc-shaped caulking portions **11***c*' are overlapped with each other when the band-shaped yoke core piece **11'** is wound in a spiral shape in the subsequent process.

The band-shaped yoke core piece **11** is taken into a manufacturing apparatus (not shown) and as shown in FIG. **25**B, the laminated yoke body **10** having a predetermined shape (see FIG. **25**B) is formed by winding and laminating the band-shaped yoke core piece **11** in a spiral shape and coupling the laminated band-shaped yoke core piece by the use of the arc-shaped caulking portions **11***c*', **11***c*', . . . in a caulking manner.

Here, by arranging the arc-shaped caulking portions **11***c*' formed in the band-shaped yoke core piece **11** in a plane shape curved in the winding direction (arrow direction R), the caulking tongues **11***t*' of the arc-shaped caulking portions **11***c*' in an upper layer are inserted into the caulking grooves **11***r*' of the arc-shaped caulking portions **11***c*' in a lower layer so as to induce the winding of the band-shaped yoke core piece **11** at the time of winding and laminating the band-shaped yoke core piece **11** in a spiral shape. Accordingly, the shaping property of the band-shaped yoke core piece **11** at the time of winding is enhanced and it is thus possible to form the laminated yoke body **10** in a circular shape.

The caulking tongues **11***t*' of the arc-shaped caulking portions **11***c*' are tilted downwardly in the winding direction (arrow direction F) of the band-shaped yoke core piece **11**. Accordingly, when the band-shaped yoke core piece **11** is wound in a spiral shape and laminated in a caulking manner, as shown in FIGS. **27**A and **27**B, the caulking tongues **11***t*' in an upper layer are slowly inserted into the caulking grooves **11***r*' in a lower layer from the front end to the base end, so the entire caulking tongues **11***t*' are smoothly and completely inserted into the caulking grooves **11***r*'. As a result, it is possible to form the laminated yoke body **10** having a large coupling strength.

FIG. **28** shows another example of the band-shaped yoke core piece **11**, wherein caulking portions **11***c*", **11***c*", . . . are arranged with a predetermined pitch in the central portion in the width direction of the band-shaped yoke core piece **11**.

Each arc-shaped caulking portion **11***c* has a caulking tongue **11***t* protruded downwardly by means of a half blanking and a caulking groove **11***r* formed at the back side of the caulking tongue **11***t* and has a plane shape curved in the winding direction (arrow direction R), that is, in the direction in which the band-shaped yoke core pieces **11** are wound in the subsequent process.

The caulking tongues **11***t*" of the arc-shaped caulking portions **11***c*" have an inverted trapezoid shape including a portion tilted downwardly in the winding direction (arrow direction F) when the band-shaped yoke core piece **11** is wound in the subsequent process and a portion tilted downwardly in the direction opposite to the winding direction (arrow direction F).

The pitch of the arc-shaped caulking portions **11***c*", **11***c*", . . . is set so that the caulking portions **11***c*" are overlapped with each other when the band-shaped yoke core piece **11** is wound in a spiral shape in the subsequent process.

By arranging the arc-shaped caulking portions **11***c*" formed in the band-shaped yoke core piece **11** in a plane shape curved in the winding direction (arrow direction R), the shaping property of the band-shaped yoke core piece **11** at the time of winding is enhanced and it is thus possible to form the laminated yoke body **10** in a circular shape.

Since the caulking tongues **11***t*" of the arc-shaped caulking portions **11***c*" are formed in an inverted trapezoid shape, the caulking tongues **11***t*" serves as a combination of the arc-shaped caulking portion **11***c* shown in FIG. **22** and the arc-shaped caulking portion **11***c*" shown in FIG. **27** when the band-shaped yoke core piece **11** is wound in a spiral shape and laminated in a caulking manner. Accordingly, the entire caulking tongues **11***t*" are smoothly and completely inserted into the caulking grooves **11***r*", so it is possible to form the laminated yoke body **10** having a large coupling strength.

In the above-mentioned embodiments, the laminated stator core including the laminated yoke body having a ring shape and the twelve laminated magnetic bodies is exemplified. However, the present invention is not limited to the manufacturing the above-mentioned laminated stator core, but may apply effectively to methods of manufacturing laminated stator cores having various structures.

Sixth Embodiment

FIGS. **29** to **36** show a method of manufacturing a laminated stator core according to a sixth embodiment of the present invention. The laminated stator core **1** manufactured according to the sixth embodiment includes an outer laminated yoke body **10** having a ring shape and a predetermined number (twelve in the sixth embodiment) of inner yoke-attachment laminated magnetic sub-bodies **20**, **20**, . . . coupled to the inner circumference of the outer laminated yoke body **10**.

The outer laminated yoke body **10** (hereinafter, referred to as laminated yoke body **10**) has a cylinder shape constituting the outer circumference of a yoke portion in the laminated stator core **1**. The laminated yoke body is manufactured by winding and laminating band-shaped yoke core sub-pieces **11**, which are formed by punching a band-shaped steel plate (metal plate), in a spiral shape and coupling them to each other in a caulking manner (caulking lamination) as described later.

Arc-shaped caulking portions **11***c*, **11***c*, . . . to be described later are formed in the band-shaped yoke core sub-pieces **11** (referred to as yoke core pieces **11**) and the laminated yoke core pieces **11** are coupled to each other through the use of the caulking portions **11***c*, **11***c*, . . . in a caulking manner.

On the other hand, each inner yoke-attachment laminated magnetic sub-body **20** (hereinafter, referred to as laminated magnetic body **20**) has an inner yoke sub-portion **20***y*, which is formed by dividing the inner half in a unit of magnetic poles when the yoke portion of the laminated yoke body **10** is divided into two halves in the width direction, and a magnetic portion **20***t* protruded from the inner yoke sub-portion **20***y*. The laminated magnetic body is manufactured by laminating a predetermined number of inner yoke-attachment magnetic core sub-pieces **21**, **21**, . . . , which are formed by punching a band-shaped steel plate (metal plate), and coupling them to each other in a caulking manner (caulking lamination). Reference numeral **21***c* in the figures denotes caulking portions formed in the inner yoke-attachment magnetic core sub-pieces **21** (hereinafter, referred to as magnetic core pieces **21**).

By connecting a predetermined number of laminated magnetic bodies **20**, **20**, . . . , which are arranged in a ring shape in the inner circumference of the laminated yoke body **10**, to each other, the laminated stator core **1** having a predetermined shape is manufactured in which a predetermined number of magnetic pole portions are protruded in the inner radius direction of the yoke portion.

A method of manufacturing the laminated stator core according to the present invention will be now described in detail by exemplifying a procedure of manufacturing the laminated stator core **1**.

First, as shown in FIG. **31**A, the yoke core pieces **11** are formed by punching a band-shaped steel plate (metal plate) not shown.

The yoke core pieces **11** have a shape that the outer half is developed in a straight line when the yoke portion of the laminated stator core **1** is divided into two halves in the width direction, that is, a band shape extending straightly with a small width. Caulking portions **11***c*, **11***c*, . . . are arranged with a predetermined pitch in the central area in the width direction of the yoke core pieces **11**.

The caulking portions **11***c* have a plane shape curved in the winding direction (arrow direction R) shown in FIG. **32**, that is, in the direction in which the yoke core pieces **11** are wound in the subsequent process, more specifically, in the circumference direction in which the caulking portions **11***c*, **11***c*, . . . are arranged in the completed laminated yoke body **10** (see FIGS. **29** and **30**). Each caulking portion has a caulking tongue **11***t* protruded downwardly through a half blanking and a caulking groove **11***r* formed at the back side of the caulking tongue **11***t*.

The pitch of the caulking portions **11***c*, **11***c*, . . . is set so that the caulking portions **11***c* are overlapped with each other when the yoke core pieces **11** are wound and laminated in a spiral shape in the subsequent process. In each caulking portion **11***c*, a caulking tongue **11***t* is tilted downwardly in the direction opposite to the winding direction (arrow direction F) when the yoke core pieces **11** are wound in the subsequent process.

After forming the band-shaped yoke core piece **11** by punching a band-shaped steel plate (metal plate), the band-shaped yoke core piece **11** is taken into a manufacturing apparatus (not shown). Then, as shown in FIG. **31**B, the laminated yoke body **10** (see FIG. **30**B) is formed by winding and laminating the band-shaped yoke core piece **11** in a spiral shape and coupling the laminated band-shaped yoke core piece by the use of the caulking portions **1**c, **11**c, . . . in a caulking manner.

Specifically, the laminated yoke body **10** is manufactured, as shown in FIG. **30**B, by suspending one end of the band-shaped yoke core piece **11** on a winding guide G of the manufacturing apparatus, winding the band-shaped yoke core piece **11** around the winding guide G rotating in the arrow direction R while taking the band-shaped yoke core piece **11** into the winding guide G in the arrow direction F, and coupling the laminated band-shaped yoke core piece **11** by the use of the caulking portions **11**c, **11**c, . . . in a caulking manner.

Here, since the band-shaped yoke core piece **11** constituting the laminated yoke body **10** has a band shape with a small width as described above, the bending processability thereof is very excellent. Accordingly, it is possible to form the laminated yoke body **10**, in which the band-shaped yoke core piece **11** is wound, in a circular shape.

By locally pressing the outer circumference of the yoke core piece **11** and stretching it in the longitudinal direction when winding the yoke core piece **11**, it is possible to further enhance the bending processability at the time of winding.

By arranging the arc-shaped caulking portions **11**c formed in the band-shaped yoke core piece **11** in a plane shape curved in the winding direction (arrow direction R), the caulking tongues **11**t of the arc-shaped caulking portions **11**c in an upper layer are inserted into the caulking grooves **11**r of the arc-shaped caulking portions **11**c in a lower layer so as to induce the winding of the band-shaped yoke core piece **11** at the time of winding and laminating the band-shaped yoke core piece **11** in a spiral shape. Accordingly, the shaping property of the band-shaped yoke core piece **11** at the time of winding is enhanced and it is thus possible to form the laminated yoke body **10** in a circular shape.

The caulking tongues **11**t of the arc-shaped caulking portions **11**c are tilted downwardly in the direction opposite to the winding direction (arrow direction F) of the band-shaped yoke core piece **11**. Accordingly, when the band-shaped yoke core piece **11** is wound in a spiral shape and laminated in a caulking manner, the caulking tongues **11**t in an upper layer are slowly inserted into the caulking grooves **11**r in a lower layer from the base end to the front end and the entire caulking tongues **11**t are completely inserted into the caulking grooves **11**r. As a result, it is possible to form the laminated yoke body **10** having a large coupling strength.

On the other hand, as shown in FIG. **33**A, the laminated magnetic body **20** is formed out of a band-shaped steel plate (metal plate) W by the use of machining stations S**1** and S**2** of a transfer press (not shown). That is, caulking portions **21**c are formed by the use of the machining station S**1** and the laminated magnetic body **20** (see FIG. **33**B) is manufactured by performing a blanking/caulking process to the magnetic core pieces **21** by the use of the machining station S**2**. The procedure of manufacturing the laminated magnetic body **20** by the use of the transfer press is not limited to the above-mentioned embodiment, but may be established properly.

Here, since each laminated magnetic body **20** is formed by laminating the magnetic core pieces **21**, **21**, . . . in a caulking manner as described above, the laminated magnetic body **20** is manufactured without departure between the laminated magnetic core pieces **21**. Accordingly, the laminated stator core **1** in which the laminated magnetic bodies **20** are coupled to the laminated yoke body **10** has very excellent shaping precision.

Since the laminated magnetic bodies **20** are formed independently of the laminated yoke body **10**, the yield of forming the magnetic core pieces **21**, **21**, . . . out of an electromagnetic steel plate (metal plate) W is enhanced. Therefore, it is possible to prevent increase in manufacturing cost.

After manufacturing the laminated magnetic bodies **20** as described above, coils L are wound around the laminated magnetic bodies **20** by the use of a specific apparatus (not shown) as shown in FIG. **33**C. As well as directly winding the coils L around the laminated magnetic bodies **20**, a bobbin (not shown) on which the coils L are wound may be mounted on the laminated magnetic bodies **20** in an additional process.

Here, since the laminated magnetic bodies **20** are separated from the laminated yoke body **10** at the time of winding the coils L around the laminated magnetic bodies **20**, the winding work of the coils L around the laminated magnetic bodies **20** is very easy. Accordingly, it is possible to wind the coils L with a high density and an excellent proportion.

After completing the winding of the coils L on the respective laminated magnetic bodies **20**, an intermediate assembly **30** in which the yoke sub-portions **20**y, **20**y, . . . form a ring shape is formed, as shown in FIG. **34**, by arranging a predetermined number of laminated magnetic bodies **20** around a ring-shaped electromagnet (magnetic adsorptive supporting means) M and connecting the ends of the inner yoke sub-portions **20**y (hereinafter, referred to as yoke sub-portions **20**y) to each other.

At this time, the laminated magnetic bodies **20**, **20**, . . . arranged around the electromagnet M are temporarily held in a ring shape very easily with the magnetic adsorptive force from the inner circumference resulting from the electromagnet M.

As described above, the laminated magnetic bodies **20**, **20**, . . . and the laminated yoke body **10** are coupled to each other, by shrink-fitting the laminated yoke body **10** to the outer circumference of the intermediate assembly **30**, as shown in FIG. **35**, after forming the intermediate assembly **30** including a predetermined number of laminated magnetic bodies **20**, **20**, ...

At this time, since the intermediate assembly **30** is formed in which the predetermined number of laminated magnetic bodies **20**, **20**, . . . are temporarily held from the inner circumference by the electromagnet M, it is possible to very easily shrink-fit the laminated yoke body **10** to the outer circumference of the intermediate assembly **30**.

As described above, by shrink-fitting the laminated yoke body **10** to the outer circumference of the intermediate assembly **30** and then separating the electromagnet M therefrom, the laminated stator core **1** having a predetermined shape is manufactured and a stator of an electric motor is completed in which the coils L are wound on the laminated magnetic bodies **20**, **20**, . . . of the laminated stator core **1**, as shown in FIG. **36**.

Here, since the laminated yoke body **10** and the intermediate assembly **30**, that is, the predetermined number of laminated magnetic bodies **20**, **20**, . . . , are coupled to each other strongly and satisfactorily by means of the shrink fitting, the shaping precision of the laminated stator core **1** is very excellent.

In this way, by the use of the method of manufacturing a laminated stator core according to the present invention, it is possible to manufacture a laminated stator core **1** excellent in shaping precision and electrical characteristic.

FIGS. **37** to **39** show another example of the laminated magnetic body constituting the laminated stator core. Here, the laminated magnetic body **20'** has a magnetic pole portion **20**t' and an inner yoke sub-portion **20**y' and a convex engagement portion **20**h' and a concave engagement portion **20**i' are formed at both ends of the inner yoke sub-portion **20**y'.

As shown in FIG. **38**A, the laminated magnetic body **20'** is formed by laminating and coupling a predetermined number of magnetic core pieces **21**A' and magnetic core pieces **21**B' formed by punching a band-shaped steel plate (metal plate) W, that is, magnetic core pieces **21**A' and magnetic core pieces **21**B' in which the lateral lengths of the inner yoke sub-portions **21**Ay' and **21**By' from the magnetic pole portions **21**At' and **21**Bt' are different from each other as shown in FIGS. **38**B and **38**C, in a caulking manner by the use of machining stations S1 and S2 of a transfer press.

As described above, in the state that the intermediate assembly **30** (see FIG. **34**) is formed by a predetermined number of laminated magnetic bodies **20'**, the laminated magnetic bodies **20'** can be strongly connected to each other, as shown in FIG. **39**, by inserting the convex engagement portion **20***h*' of a laminated magnetic body **20'** into the concave engagement portion **20***i*' of the laminated magnetic body **20'** adjacent thereto. Accordingly, it is possible to greatly enhance the mechanical strength of the laminated stator core and to maintain the shaping precision of the laminated stator core.

In the above-mentioned embodiments, the laminated stator core including the laminated yoke body having a ring shape and the twelve laminated magnetic bodies is exemplified. However, the present invention is not limited to the manufacturing the above-mentioned laminated stator core, but may apply effectively to methods of manufacturing laminated stator cores having various structures.

Seventh Embodiment

FIGS. **40** to **46** show a method of manufacturing a laminated stator core according to a seventh embodiment of the present invention. The laminated stator core **1** manufactured according to the seventh embodiment includes an outer laminated yoke body **10** having a ring shape and a predetermined number (twelve in the seventh embodiment) of inner yoke-attachment laminated magnetic sub-bodies **20**, **20**, . . . coupled to the inner circumference of the outer laminated yoke body **10**.

The outer laminated yoke body **10** (hereinafter, referred to as the laminated yoke body **10**) has a cylinder shape constituting the outer circumference of a yoke portion in the laminated stator core **1**. The laminated yoke body is manufactured by winding and laminating band-shaped yoke core sub-pieces **11**, which are formed by punching a band-shaped steel plate (metal plate), in a spiral shape and coupling them to each other in a caulking manner (caulking lamination) as described later. A predetermined number (twelve in the seventh embodiment) of concave connection portions **11***a*, **11***a*, . . . are formed in the inner circumferential edge of the laminated yoke body **10**.

Arc-shaped caulking portions **11***c*, **11***c*, . . . to be described later are formed in the band-shaped yoke core sub-pieces **11** (referred to as yoke core pieces **11**) and the laminated yoke core pieces **11** are coupled to each other through the use of the caulking portions **11***c*, **11***c*, . . . in a caulking manner.

On the other hand, each inner yoke-attachment laminated magnetic sub-body **20** (hereinafter, referred to as laminated magnetic body **20**) has an inner yoke sub-portion **20***y*, which is formed by dividing the inner half in a unit of magnetic pole when the yoke portion of the laminated yoke body **10** is divided into two halves in the width direction, and a magnetic pole portion **20***t* protruded from the inner yoke sub-portion **20***y*. A convex connection portion **21***a* is formed at the backside of the inner yoke sub-portion **20***y* (hereinafter, referred to as yoke sub-portion **20***y*).

As described later, the laminated magnetic-pole body **10** is constructed by laminating and coupling a predetermined number of inner yoke-attachment magnetic core sub-pieces **21**, **21**, . . . , which is formed by punching a band-shaped steel plate (metal plate), to each other in a caulking manner (caulking lamination). Reference numeral **21***c* in the figures denotes a caulking portion formed in each inner yoke-attachment magnetic core sub-piece **21** (hereinafter, referred to as magnetic core piece **21**).

By connecting a predetermined number of laminated magnetic bodies **20**, **20**, . . . , which are arranged in a ring shape in the inner circumference of the laminated yoke body **10**, to each other, the laminated stator core **1** having a predetermined shape is manufactured in which a predetermined number of magnetic pole portions are protruded in the inner radius direction of the yoke portion.

The method of manufacturing the laminated stator core according to the present invention will be now described in detail by exemplifying a procedure of manufacturing the laminated stator core **1**.

First, as shown in FIG. **42**A, the yoke core pieces **11** are formed by punching a band-shaped steel plate (metal plate) not shown.

The yoke core pieces **11** have a shape that the outer half is developed in a straight line when the yoke portion of the laminated stator core **1** is divided into two halves in the width direction, that is, a band shape extending straightly with a small width. Caulking portions **11***c*, **11***c*, . . . are arranged with a predetermined pitch in the central area in the width direction of the yoke core pieces **11**. Concave connection portions **11***a*, **11***a*, . . . are arranged with a predetermined pitch in the inner circumferential edge **11***i* thereof, that is, in the portion constituting the inner circumference of the laminated yoke body **10** (see FIG. **41**) when the yoke core pieces are wound in the subsequent process.

Here, the pitch of the caulking portions **11***c*, **11***c*, . . . is set so that the caulking portions **11***c* are overlapped with each other when the yoke core pieces **11** are wound and laminated in a spiral shape in the subsequent process. Similarly, the pitch of the concave connection portions **11***a*, **11***a*, . . . is set so that the concave connection portions **11***a* are overlapped with each other when the yoke core pieces **11** are wound and laminated in a spiral shape in the subsequent process.

The caulking portions **11***c* have a plane shape curved in the winding direction (arrow direction R) shown in FIG. **43**, that is, in the direction in which the yoke core pieces **11** are wound in the subsequent process, more specifically, in the circumference direction in which the caulking portions **11***c*, **11***c*, . . . are arranged in the completed laminated yoke body **10** (see FIGS. **40** and **41**).

Each caulking portion **11***c* has a caulking tongue **11***t* protruded downwardly by means of a half blanking and a caulking groove **11***r* formed at the back side of the caulking tongue **11***t*, as shown in FIG. **43**. The caulking tongue **11***t* is tilted downwardly in the direction opposite to the winding direction (arrow direction F) when the yoke core pieces **11** are wound in the subsequent process.

After forming the band-shaped yoke core piece **11** by punching a band-shaped steel plate (metal plate), the band-shaped yoke core piece **11** is taken into a manufacturing apparatus (not shown). Then, as shown in FIG. **42**B, the laminated yoke body **10** (see FIG. **41**B) is formed by winding and laminating the band-shaped yoke core piece **11** in a spiral shape and coupling the laminated band-shaped yoke core piece by the use of the caulking portions **11***c*, **11***c*, . . . in a caulking manner.

Specifically, the laminated yoke body **10** is manufactured, as shown in FIG. **41**B, by suspending one end of the band-shaped yoke core piece **11** on a winding guide G of the manufacturing apparatus, winding the band-shaped yoke core piece **11** around the winding guide G rotating in the arrow direction R while taking the band-shaped yoke core piece **11** into the winding guide G in the arrow direction F, and coupling the laminated hand-shaped yoke core piece **11** by the use of the caulking portions **11***c*, **11***c*, . . . in a caulking manner.

Here, since the band-shaped yoke core piece **11** constituting the laminated yoke body **10** has a band shape with a small width as described above and the concave connection portions **11***a*, **11***a*, . . . are formed in the inner circumferential edge **11***i* thereof, bending processability thereof is very excellent. Accordingly, it is possible to form the laminated yoke body **10**, in which the band-shaped yoke core piece **11** is wound, in a circular shape.

As shown in FIGS. **41** and **42**, by forming the edges of the concave connection portion **11***a* of the yoke core piece **11** into a round shape, it is possible to further enhance the bending processability (winding formability).

By locally pressing the outer circumference of the yoke core piece **11** and stretching it in the longitudinal direction when winding the yoke core piece **11**, it is possible to further enhance the bending processability at the time of winding.

By arranging the arc-shaped caulking portions **11***c* formed in the band-shaped yoke core piece **11** in a plane shape curved in the winding direction (arrow direction R), the caulking tongues **11***t* of the arc-shaped caulking portions **11***c* in an upper layer are inserted into the caulking grooves **11***r* of the arc-shaped caulking portions **11***c* in a lower layer so as to induce the winding of the band-shaped yoke core piece **11** at the time of winding and laminating the band-shaped yoke core piece **11** in a spiral shape. Accordingly, the shaping property of the band-shaped yoke core piece **11** at the time of winding is enhanced and it is thus possible to form the laminated yoke body **10** in a circular shape.

The caulking tongues **11***t* of the arc-shaped caulking portions **11***c* are tilted downwardly in the direction opposite to the winding direction (arrow direction F) of the band-shaped yoke core piece **11**. Accordingly, when the band-shaped yoke core piece **11** is wound in a spiral shape and laminated in a caulking manner, the caulking tongues **11***t* in an upper layer are slowly inserted into the caulking grooves **11***r* in a lower layer from the base end to the front end and the entire caulking tongues **11***t* are completely inserted into the caulking grooves **11***r*. As a result, it is possible to form the laminated yoke body **10** having a large coupling strength.

On the other hand, as shown in FIG. **44**A, the laminated magnetic body **20** is formed from a band-shaped steel plate (metal plate) W by the use of machining stations S and S**2** of a transfer press (not shown). That is, the caulking portions **21***c* are formed by use of the machining station S**1** and the laminated magnetic body **20** (see FIG. **44**B) is manufactured by shaping and laminating the magnetic core pieces **21** in a caulking manner by the use of the machining station S**2**. The procedure of manufacturing the laminated magnetic body **20** by the use of the transfer press is not limited to the above-mentioned embodiment, but may be set up properly.

Here, since the laminated magnetic body **20** is formed by laminating the magnetic core pieces **21**, **21**, . . . in a caulking manner as described above, the laminated magnetic body **20** is manufactured without departure between the laminated magnetic core pieces **21**. Accordingly, the laminated stator core **1** in which the laminated magnetic bodies **20** are coupled to the laminated yoke body **10** has very excellent shaping precision.

Since the laminated magnetic bodies **20** are formed independently of the laminated yoke body **10**, the yield of forming the magnetic core pieces **21**, **21**, . . . out of an electromagnetic steel plate (metal plate) W is enhanced. Therefore, it is possible to prevent increase in manufacturing cost.

After manufacturing the laminated magnetic bodies **20** as described above, coils L are wound around the laminated magnetic bodies **20** by the use of a specific apparatus (not shown) as shown in FIG. **44**C. As well as directly winding the coils L around the laminated magnetic bodies **20**, a bobbin (not shown) on which the coils L are wound may be mounted on the laminated magnetic bodies **20** in an additional process.

Here, since the laminated magnetic bodies **20** are separated from the laminated yoke body **10** at the time of winding the coils L around the laminated magnetic bodies **20**, the winding work of the coils L around the laminated magnetic bodies **20** is very easy. Accordingly, it is possible to wind the coils L with a high density and an excellent proportion.

After completing the winding of the coils L on a predetermined number of laminated magnetic bodies **20**, the laminated magnetic bodies **20** are coupled to the laminated core body **10** by inserting the convex connection portions **21***a* of the laminated magnetic bodies **20** into the concave connection portions **11***a* of the laminated yoke body **10** along the diameter direction of the laminated yoke body **10**, as shown in FIG. **45**.

As described above, by inserting the convex connection portions **21***a* of the laminated magnetic bodies **20** into the concave connection portions **11***a* of the laminated yoke body **10** and coupling the laminated yoke body **10** and the laminated magnetic bodies **20** to each other, the laminated stator core **1** having a predetermined shape is manufactured and a stator of an electric motor is completed in which the coils L are wound on the laminated magnetic bodies **20**, **20**, . . . of the laminated stator core **1**, as shown in FIG. **46**.

Here, since the laminated yoke body **10** and the respective laminated magnetic bodies **20**, **20**, . . . are strongly and satisfactorily coupled to each other by inserting the convex connection portions **21***a* of the laminated magnetic bodies **20** into the concave connection portions **11***a* of the laminated yoke body **10**, the shaping precision of the laminated stator core is very excellent.

In this way, by the use of the method of manufacturing a laminated stator core according to the present invention, it is possible to manufacture a laminated stator core **1** excellent in material yield, shaping precision, and electrical characteristic.

On the other hand, after completing the winding of the coils L on the respective laminated magnetic bodies **20**, an intermediate assembly **30** in which the yoke sub-portions **20***y*, **20***y*, . . . form a ring shape is formed, as shown in FIG. **47**, by arranging a predetermined number of laminated magnetic bodies **20** around a ring-shaped electromagnet (magnetic adsorptive supporting means) M and connecting the ends of the inner yoke sub-portions **20***y* (hereinafter, referred to as yoke sub-portions **20***y*) to each other.

At this time, the laminated magnetic bodies **20**, **20**, . . . arranged around the electromagnet M are temporarily held in a ring shape very easily with the magnetic adsorptive force from the inner circumference resulting from the electromagnet M.

As described above, the laminated magnetic bodies **20**, **20**, . . . and the laminated yoke body **10** are coupled to each other, by shrink-fitting the laminated yoke body **10** to the outer circumference of the intermediate assembly **30** and inserting the convex connection portions **21***a* of the laminated magnetic bodies **20** into the concave connection portions **11***a* of the laminated yoke body, as shown in FIG. **48**, after forming the intermediate assembly **30** including a predetermined number of laminated magnetic bodies **20**, **20**, ...

At this time, since the intermediate assembly **30** is formed in which the predetermined number of laminated magnetic bodies **20**, **20**, . . . are temporarily held from the inner circumference by the electromagnet M, it is possible to very easily shrink-fit the laminated yoke body **10** to the outer circumference of the intermediate assembly **30**.

As described above, by shrink-fitting the laminated yoke body **10** to the outer circumference of the intermediate assembly **30** and then separating the electromagnet M therefrom, the laminated stator core **1** having a predetermined shape is manufactured and a stator of an electric motor is completed in which the coils L are wound on the laminated magnetic bodies **20**, **20**, . . . of the laminated stator core **1**, as shown in FIG. **7**.

Here, since the laminated yoke body **10** and the intermediate assembly **30**, that is, a predetermined number of laminated magnetic bodies **20**, **20**, . . . , are strongly and satisfactorily coupled to each other by shrink-fitting, the shaping precision of the laminated stator core is very excellent.

In addition, since the laminated yoke body **10** and the respective laminated magnetic bodies **20**, **20**, . . . are strongly and satisfactorily coupled to each other by inserting the convex connection portions **21***a* of the laminated magnetic bodies **20** into the concave connection portions **11***a* of the laminated yoke body **10**, the shaping precision of the laminated stator core is more excellent.

In this way, by the use of the method of manufacturing a laminated stator core according to the present invention, it is possible to manufacture a laminated stator core **1** excellent in material yield, shaping precision, and electrical characteristic.

FIGS. **49** to **51** show another example of the laminated magnetic body constituting the laminated stator core. Here, the laminated magnetic body **20'** has a magnetic pole portion **20***t*', an inner yoke sub-portion **20***y*', a convex connection portion **21***a*' and a convex engagement portion **20***h*' and a concave engagement portion **20***i*' are formed at both ends of the inner yoke sub-portion **20***y*'.

As shown in FIG. **50**A, the laminated magnetic body **20'** is formed by laminating and coupling a predetermined number of magnetic core pieces **21**A' and magnetic core pieces **21**B' formed by punching a band-shaped steel plate (metal plate) W, that is, magnetic core pieces **21**A' and magnetic core pieces **21**B' in which the lateral lengths of the inner yoke sub-portions **21**Ay' and **21**By' from the magnetic pole portions **21**At' and **21**Bt' are different from each other as shown in FIGS. **50**B and **50**C, in a caulking manner by the use of machining stations S1 and S2 of a transfer press.

As described above, in the state that a predetermined number of laminated magnetic bodies **20'** are arranged in a ring shape in the inner circumference of the laminated yoke body **10** (see FIG. **46**), or in the state that the intermediate assembly **30** (see FIG. **47**) is formed by a predetermined number of laminated magnetic bodies **20'**, the laminated magnetic bodies **20'** can be strongly connected to each other, as shown in FIG. **51**, by inserting the convex engagement portion **20***h*' of a laminated magnetic body **20'** into the concave engagement portion **20***i*' of the laminated magnetic body **20'** adjacent thereto. Accordingly, it is possible to greatly enhance the mechanical strength of the laminated stator core and to maintain the shaping precision of the laminated stator core.

In the above-mentioned embodiments, the laminated stator core including the laminated yoke body having a ring shape and the twelve laminated magnetic bodies is exemplified. However, the present invention is not limited to the manufacturing the above-mentioned laminated stator core, but may apply effectively to methods of manufacturing laminated stator cores having various structures.

Eighth Embodiment

FIGS. **52** to **56** show a method of manufacturing a laminated rotor core according to an eighth embodiment. The laminated rotor core **1** manufactured according to the eighth embodiment is an element constituting a magnet-attached rotor **100** (see FIG. **56**) and has a ring shape including a rotation shaft fitting hole (shaft hole) **1**O at the center thereof. Magnet fitting holes **1**M, **1**M, . . . are arranged all around the outer circumference thereof.

The laminated rotor core **1** is manufactured by winding and laminating a band-shaped core piece **10**, which is formed by punching a metal plate as described later, in a spiral shape and coupling the laminated band-shaped core piece in a caulking manner. Reference numeral **10***c* in the figures denotes a caulking portion formed in the band-shaped core piece **10**.

Reference numerals **10***p*, **10***p*, . . . in the figures denote pressed portions formed when winding the band-shaped core piece **10** as described later and reference numerals **10***n*, **10***n*, . . . in the figures denote cut portions closed when winding the band-shaped core piece **10** as described later.

Now, a method of manufacturing a laminated rotor core according to an embodiment of the present invention will be described in detail by exemplifying the above-mentioned laminated rotor core **1**.

First, as shown in FIG. **53**A, the band-shaped core piece **10** is formed by punching a metal plate not shown.

The band-shaped core piece **10** has a shape that the laminated rotor core **1** is developed in a straight line, that is, a band shape extending straightly. Cut portions **10***n*, **10***n*, . . . are arranged with a predetermined pitch (interval) in the inner circumferential edge **10***i*, that is, in a portion constituting the inner circumference of the laminated rotor core **1** (see FIG. **52**) when the band-shaped core piece **10** is wound in the subsequent process.

The respective cut portions **10***n*, **10***n*, . . . have a V shape opened toward the edge of the band-shaped core piece **10** and the vertex thereof extends to the center area in the width direction of the band-shaped core piece **10**.

The inner circumferential edge portion **10***e* between the adjacent cut portions **10***n* formed in the inner circumferential edge **10***i* has an arc shape corresponding to the inner circumference of the rotation shaft fitting hole (shaft hole) **1**O in the completed laminated rotor core **1** (see FIG. **52**), that is, an arc shape having the radius r of the rotation shaft fitting hole **1**O as a radius of curvature as shown in FIG. **54**.

Caulking portions **10***c*, **10***c*, . . . are arranged with a predetermined pitch in the inner circumferential edge **10***i* and the outer circumferential edge **10***o* of the band-shaped core piece **10**. The formation pitch of the caulking portions **10***c*, **10***c*, . . . is set so that the caulking portions **10***c* are overlapped with each other when the band-shaped core piece **10** is wound and laminated in a spiral shape in the subsequent process.

Rectangular magnet fitting holes **10***m*, **10***m*, . . . are formed with a predetermined pitch (interval) in the intermediate portion in the width direction of the bad-shaped core piece **10**, specifically, in a portion close to the outer circumferential edge **10***o* in the intermediate portion. The formation pitch of the magnet fitting holes **10***m*, **10***m*, . . . is set so that the magnet fitting holes **10**_m_ are overlapped with each other to form a penetrated mage not fitting hole **10**M (see FIG. **52**) when the band-shaped core piece **10** is wound and laminated in a spiral shape in the subsequent process.

Here, the formation pitch (interval) of the cut portions **10**_n_ or the size (size in the width direction of the band-shaped core piece **10** and spread angle of the V shape) of the cut portions **10**_n_ in the band-shaped core piece **10** and the formation pitch (interval) or shape of the magnet fitting holes **10**_m_ can be set properly based on specifications of the laminated rotor core **1** to be manufactured.

After forming the band-shaped core piece **10** by punching a metal plate as described above, the band-shaped core piece **10** is taken into a manufacturing apparatus (not shown). Then, as shown in FIG. **53**B, the laminated rotor core **1** (see FIG. **52**) is manufactured by locally pressing the outer circumferential edge **10**_o_ of the band-shaped core piece **10** to roll the band-shaped core piece, winding and laminating the band-shaped core piece **10** in a spiral shape, and coupling the laminated band-shaped yoke core piece by the use of the caulking portions **10**_c_, **10**_c_, . . . in a caulking manner.

Specifically, the band-shaped core piece **10** is bent by suspending one end of the band-shaped core piece **10** on a winding guide G of the manufacturing apparatus and winding the band-shaped core piece **10** on the winding guide G rotating in the arrow direction R while taking the band-shaped core piece **10** into the winding guide G in the arrow direction F.

At this time, before bending the hand-shaped core piece **10** by winding the band-shaped core piece on the winding guide G, the outer circumferential edge **10**_o_ is locally pressed to roll the band-shaped core piece, as shown in FIG. **53**B, by forming by pressing pressed portions **10**_p_ in the outer circumferential edge **10**_o_ of the band-shaped core piece **10**.

Here, the pressed portions **10**_p_ have a semi-circular shape as shown in FIG. **55** and are formed in the outer circumferential edge portion **10**_f_ of the band-shaped core piece **10**. The formation area is widened toward the outer circumferential edge portion **10**_f_.

The pressed portions **10**_p_, **10**_p_, . . . are formed by press with a predetermined pitch (interval) in the outer circumferential edge **10**_o_ with movement of the band-shaped core piece **10**.

The laminated rotor core **1** having a predetermined shape is manufactured, as shown in FIG. **52**, by forming the pressed portions **10**_p_, **10**_p_, . . . in the outer circumferential edge **10**_o_ of the band-shaped core piece **10**, winding the band-shaped core piece **10** on the winding guide G rotating, and coupling the band-shaped core piece **10** laminated by a predetermined number of layers by the use of the caulking portions **10**_c_, **10**_c_, . . . in a caulking manner.

Since the cut portions **10**_n_, **10**_n_, . . . are formed with a predetermined pitch in the inner circumferential edge **10**_i_, the band-shaped core piece **10** can be easily bent without applying a surface compression to the inner circumferential edge **10**_i_ when it is wound in a spiral shape by a manufacturing apparatus (not shown).

When the band-shaped core piece **10** is wound in a spiral shape by the manufacturing apparatus (not shown), the outer circumferential edge **10**_o_ is locally pressed to roll the band-shaped core piece due to the pressed portions **10**_p_, **10**_p_, . . . formed in the outer circumferential edge **10**_o_. Accordingly, the band-shaped core piece can be easily bent.

Since magnet fitting holes **10**_m_, **10**_m_, . . . are formed in the intermediate portion in the width direction of the band-shaped core piece **10**, the shaping property of the intermediate portion is improved. Accordingly, when the band-shaped core piece is wound in a spiral shape by the manufacturing apparatus (not shown), the band-shaped core piece can be easily bent.

In this way, since the band-shaped core piece **10** is excellent in bending formability when it is wound in a spiral shape, the band-shaped core piece **10** can be wound in a circular shape. Accordingly, it is possible to manufacture a laminated rotor core **1** having excellent shaping precision.

According to the above-mentioned method of manufacturing the laminated rotor core **1**, since the laminated rotor core **1** is manufactured by winding and laminating the band-shaped core piece **10** in a spiral shape, it is possible to greatly enhance the productivity of the laminated rotor core **1**, in comparison with the conventional manufacturing method in which a rotor core formed by winding a band-shaped plate in a ring shape is laminated sheet by sheet (see FIGS. **66** and **67**).

In addition, in the method of manufacturing the laminated rotor core **1** described above, since the shaft hole **1**O of the laminated rotor core **1** formed by winding the band-shaped core piece **10** has a circular shape by forming the inner circumferential edge **10**_e_ between the cut portions **10**_n_ in the band-shaped core piece **10** in an are shape corresponding to the inner circumference of the shaft hole **1**O, a re-grinding process is not necessary. Accordingly, it is possible to greatly improve the productivity of the laminated rotor core **1**.

Since the resistance (surface compression) at the time of winding the band-shaped core piece **10** in a spiral shape is considerably reduced by forming the cut portions **10**_n_, **10**_n_, . . . in the inner circumferential edge **10**_i_ of the band-shaped core piece **10** to extend to the center in the width direction of the band-shaped core piece **10**, it is possible to easily wind the band-shaped core piece **10** and to further enhance the shaping precision of the laminated rotor core **1**.

Since the outer circumference of the band-shaped core piece **10** is more expanded by press by forming the areas of the pressed portions **10**_p_, **10**_p_, . . . formed in the outer circumferential edge **20**_o_ of the hand-shaped core piece **10** so that the area is widened toward the outer circumference edge portion **10**_f_, it is possible to easily wind the band-shaped core piece **10**. Accordingly, the shaping precision of the laminated rotor core **1** is further enhanced.

Since the pressed portions **10**_p_, **10**_p_, . . . formed by locally pressing the outer circumferential edge **10**_o_ of the band-shaped core piece **10** exist not continuously but locally (intermittently), the appearance of the laminated rotor core **1** is not deteriorated. In addition, since dust does not invade the laminated rotor core, it is possible to elongate a lifetime of the laminated rotor core **1**.

A magnet attached rotor **100** in which magnet blocks **15** are mounted on the laminated rotor core **1** as shown in FIG. **56**B is completed by manufacturing the laminated rotor core **1** as described above and inserting the magnet blocks **15**, **15**, . . . made of ferrite magnet or rare earth magnet into the magnet fitting holes **1**M, **1**M, . . . of the laminated rotor core **1** as shown in FIG. **56**A.

FIGS. **57** to **61** show an example of the method of manufacturing a laminated rotor core according to the present invention. The laminated rotor core **2** manufactured according to the present invention is an element constituting a diecast attached rotor **200** (see FIG. **61**) and has a ring shape including a rotation shaft fitting hole (shaft hole) **2**O. Diecast metal filling holes **2**D, **2**D, . . . are arranged all around the outer circumference thereof.

The laminated rotor core **2** is manufactured by winding and laminating a band-shaped core piece **20**, which is formed by punching a metal plate as described later, in a spiral shape and coupling the laminated band-shaped core piece in a caulking manner. Reference numeral **20***c*, **20***c*, . . . in FIG. **57** denote caulking portions formed in the band-shaped core piece **20**.

Reference numerals **20***p*, **20***p*, . . . in FIG. **57** denote pressed portions formed when winding the band-shaped core piece **20** as described later and reference numerals **20***n*, **20***n*, . . . in FIG. **57** denote cut portions closed when winding the band-shaped core piece **20** as described later.

Now, a method of manufacturing a laminated rotor core according to an embodiment of the present invention will be described in detail by exemplifying the above-mentioned laminated rotor core **2**.

First, as shown in FIG. **58**A, the band-shaped core piece **20** is formed by punching a metal plate not shown.

The band-shaped core piece **20** has a shape that the laminated rotor core **2** is developed in a straight line, that is, a band shape extending straightly. Cut portions **20***n*, **20***n*, . . . are arranged with a predetermined pitch (interval) in the inner circumferential edge **20***i*, that is, in a portion constituting the inner circumference of the laminated rotor core **2** (see FIG. **57**) when the band-shaped core piece **20** is wound in the subsequent process.

The respective cut portions **20***n*, **20***n*, . . . have a V shape opened toward the edge of the band-shaped core piece **20** and the vertex thereof extends to the center area in the width direction of the band-shaped core piece **20**.

The inner circumferential edge portion **20***e* between the adjacent cut portions **20***n* formed in the inner circumferential edge **20***i* has an arc shape corresponding to the inner circumference of the rotation shaft fitting hole (shaft hole) 2O in the completed laminated rotor core **2** (see FIG. **57**), that is, an arc shape having the radius r of the rotation shaft fitting hole 2O as a radius of curvature as shown in FIG. **59**.

Caulking portions **20***c*, **20***c*, . . . are arranged with a predetermined pitch in the inner circumferential edge **20***i* and the outer circumferential edge **20***o* of the band-shaped core piece **20**. The formation pitch of the caulking portions **20***e*, **20***c*, . . . is set so that the caulking portions **20***c* are overlapped with each other when the band-shaped core piece **20** is wound and laminated in a spiral shape in the subsequent process.

Rectangular diecast metal filling holes **20***d*, **20***d*, . . . are formed with a predetermined pitch (interval) in the intermediate portion in the width direction of the bad-shaped core piece **20**, specifically, in a portion close to the outer circumferential edge **20***o* in the intermediate portion. The formation pitch of the diecast metal filling holes **20***d*, **20***d*, . . . is set so that the diecast metal filling holes **20***d* are overlapped with each other to form a penetrated diecast metal filling hole **2**D (see FIG. **57**) when the band-shaped core piece **20** is wound and laminated in a spiral shape in the subsequent process.

Here, the formation pitch (interval) of the cut portions **20***n* or the size (size in the width direction of the band-shaped core piece **20**, spread angle of the V shape) of the cut portions **20***n* in the band-shaped core piece **20** and the formation pitch (interval) or shape of the diecast metal filling holes **20***d* can be set properly based on specifications of the laminated rotor core **2** to be manufactured.

After forming the band-shaped core piece **20** by punching a metal plate as described above, the band-shaped core piece **20** is taken into a manufacturing apparatus (not shown). Then, as shown in FIG. **58**B, the laminated rotor core **2** (see FIG. **57**) is manufactured by locally pressing the outer circumferential edge **20***o* of the band-shaped core piece **20** to roll the band-shaped core piece, winding and laminating the band-shaped core piece **20** in a spiral shape, and coupling the laminated band-shaped yoke core piece by the use of the caulking portions **20***c*, **20***c*, . . . in a caulking manner.

Specifically, the band-shaped core piece **20** is bent by suspending one end of the band-shaped core piece **20** on a winding guide G of the manufacturing apparatus and winding the band-shaped core piece **20** on the winding guide G rotating in the arrow direction R while taking the band-shaped core piece **20** into the winding guide G in the arrow direction F.

At this time, before bending the band-shaped core piece **20** by winding the band-shaped core piece on the winding guide G, the outer circumferential edge **20***o* is locally pressed to roll the band-shaped core piece, as shown in FIG. **58**B, by forming by pressing pressed portions **20***p* in the outer circumferential edge **20***o* of the band-shaped core piece **20**.

Here, the pressed portions **20***p* have a semi-circular shape as shown in FIG. **60** and are formed in the outer circumferential edge portion **20***f* of the band-shaped core piece **20**. The formation area is widened toward the outer circumferential edge portion **20***f*.

The pressed portions **20***p*, **20***p*, . . . are formed by press with a predetermined pitch (interval) in the outer circumferential edge **20***o* with movement of the band-shaped core piece **20**.

The laminated rotor core **2** having a predetermined shape is manufactured, as shown in FIG. **57**, by forming the pressed portions **20***p*, **20***p*, . . . in the outer circumferential edge **20***o* of the band-shaped core piece **20**, winding the band-shaped core piece **20** on the winding guide G rotating, and coupling the band-shaped core piece **20** laminated by a predetermined number of layers by the use of the caulking portions **20***c*, **20***c*, . . . in a caulking manner.

Since the cut portions **20***n*, **20***n*, . . . are formed with a predetermined pitch in the inner circumferential edge **20***i*, the band-shaped core piece **20** can be easily bent without applying a surface compression to the inner circumferential edge **20***i* when it is wound in a spiral shape by a manufacturing apparatus (not shown).

When the band-shaped core piece **20** is wound in a spiral shape by the manufacturing apparatus (not shown), the pressed portions **20***p*, **20***p*, . . . are formed in the outer circumferential edge **20***o*. Accordingly, the outer circumferential edge **20***o* is locally pressed to roll the band-shaped core piece, thereby, easily bending the band-shaped core piece.

In addition, since the diecast metal filling holes **20***d*, **20***d*, . . . are formed in the intermediate portion in the width direction of the band-shaped core piece **20**, the shaping property of the intermediate portion is improved. Accordingly, it is possible to easily bend the band-shaped core piece **20** when it is wound in a spiral shape by a manufacturing apparatus (not shown).

In this way, since the bending processability of the band-shaped core piece **20** is very excellent when it is wound in a spiral shape, it is possible to wind the band-shaped core piece **20** in a circular shape. Accordingly, it is possible to manufacture the laminated rotor core **2** having excellent shaping precision.

According to the above-mentioned method of manufacturing the laminated rotor core **2**, since the laminated rotor core **2** is manufactured by winding and laminating the band-shaped core piece **20** in a spiral shape, it is possible to greatly enhance the productivity of the laminated rotor core **2**, in comparison with the conventional manufacturing method in which a rotor core formed by winding a band-shaped plate in a ring shape is laminated sheet by sheet (see FIGS. **66** and **67**).

In addition, in the method of manufacturing the laminated rotor core **2** described above, since the shaft hole 2O of the laminated rotor core **2** formed by winding the band-shaped core piece **20** has a circular shape by forming the inner circumferential edge **20***e* between the cut portions **20***n* in the band-shaped core piece **20** in an arc shape corresponding to the inner circumference of the shaft hole 2O, a re-grinding process is not necessary. Accordingly, it is possible to greatly improve the productivity of the laminated rotor core **2**.

Since the resistance (surface compression) at the time of winding the band-shaped core piece **20** in a spiral shape is considerably reduced by forming the cut portions **20***n*, **20***n*, . . . in the inner circumferential edge **20***i* of the hand-shaped core piece **20** to extend to the center in the width direction of the hand-shaped core piece **20**, it is possible to easily wind the band-shaped core piece **210** and to further enhance the shaping precision of the laminated rotor core **2**.

Since the outer circumference of the band-shaped core piece **20** is more expanded by press by forming the areas of the pressed portions **20***p*, **20***p*, . . . formed in the outer circumferential edge **20***o* of the band-shaped core piece **20** so that the area is widened toward the outer circumference edge portion **20***f*, it is possible to easily wind the band-shaped core piece **20**. Accordingly, the shaping precision of the laminated rotor core **2** is further enhanced.

Since the pressed portions **20***p*, **20***p*, . . . formed by locally pressing the outer circumferential edge **20***o* of the band-shaped core piece **20** exist not continuously but locally (intermittently), the appearance of the laminated rotor core **2** is not deteriorated. In addition, since dust does not invade the laminated rotor core, it is possible to elongate a lifetime of the laminated rotor core **2**.

A diecast-attached rotor **200** in which magnet diecast metal blocks **25** are mounted on the laminated rotor core **2** as shown in FIG. **61**B is completed by filling (die-casting) the diecast metal filling holes 2D, 2D, . . . of the laminated rotor core **2** with the melted diecast metal (for example, aluminum) **25** as shown in FIG. **61**A, after manufacturing the laminated rotor core **2** as described above.

Although the present invention has been described in detail with reference to specific embodiments, it can be understood by those skilled in the art that various modifications may be applied thereto without departing from the spirit and scope of the present invention.

This application is based on Japanese Patent Application No. 2004-262541 filed on Sep. 9, 2004, Japanese Patent Application No. 2004-311198 filed on Oct. 26, 2004, Japanese Patent Application No. 2004-325201 filed on Nov. 9, 2004, Japanese Patent Application No. 2004-340510 filed on Nov. 25, 2004, Japanese Patent Application No. 2004-340511 filed on Nov. 25, 2004, and Japanese Patent Application No. 2004-349848 filed on Dec. 2, 2004, the disclosure of which is incorporated herein in its entirety by reference.

INDUSTRIAL APPLICABILITY

According to the present invention, it is possible to manufacture a laminated core excellent in shaping precision and electrical characteristic, by using a method of manufacturing a laminated core in which a band-shaped core piece is wound and laminated in a spiral shape.

The invention claimed is:

1. A method of manufacturing a laminated stator core, comprising the steps of:

- forming a band-shaped yoke core sub-piece having a shape that an outer half is developed in a straight line when a yoke portion of the laminated stator core is divided into two halves in the width direction by punching a metal plate;
- forming an outer laminated yoke body by winding and laminating the band-shaped yoke core sub-piece in a spiral shape and coupling it in a caulking manner;
- forming an inner yoke-attachment magnetic core sub-piece having an inner yoke sub-portion obtained by dividing the inner half in a unit of magnetic poles when the yoke portion of the laminated stator core is divided into two halves in the width direction, by punching a metal plate;
- forming an inner yoke-attachment laminated magnetic sub-body by laminating and coupling a predetermined number of the inner yoke-attachment magnetic core sub-pieces to each other in a caulking manner;
- forming an intermediate assembly in which the inner yoke sub-portions form a ring shape by winding a coil on the inner yoke-attachment laminated magnetic sub-body and connecting the ends of the inner yoke sub-portions in a predetermined number of the inner yoke-attachment laminated magnetic sub-bodies to each other; and
- coupling the inner yoke-attachment laminated magnetic sub-bodies to the outer laminated yoke body by shrink-fitting the outer laminated yoke body to the outer circumference of the intermediate assembly.

2. The method according to claim **1**, wherein in the forming the intermediate assembly, a predetermined number of the inner yoke-attachment laminated magnetic sub-bodies are temporarily held from the inner circumference by the use of a magnetic adsorptive supporting means.

3. The method according to claim **1**, wherein each inner yoke-attachment laminated magnetic sub-body is formed by coupling a predetermined number of the inner yoke-attachment magnetic core sub-pieces having different lengths from a magnetic pole portion to an end of each inner yoke sub-portion and a convex engagement portion and a concave engagement portion are formed at both ends of each inner yoke sub-portion, respectively, and wherein in the forming the intermediate assembly, the convex engagement portion of each inner yoke-attachment laminated magnetic sub-body is inserted into the concave engagement portion of the inner yoke-attachment laminated magnetic sub-body adjacent thereto.

4. The method according to claim **1**, wherein concave connection portions are formed in the inner circumferential edge of the band-shaped yoke core sub-piece which is the outer half when the yoke portion of the laminated stator core is divided into two halves in the width direction,

- wherein convex connection portions are formed at the back side of the inner yoke sub-portion which is the inner half when the yoke portion of the laminated stator core is divided into two halves in the width direction, and
- wherein the inner yoke-attachment laminated magnetic sub-body is coupled to the outer laminated yoke body by inserting the convex connection portions into the concave connection portions.

5. The method according to claim **4**, wherein in the forming the intermediate assembly, a predetermined number of the inner yoke-attachment laminated magnetic sub-bodies are temporarily held from the inner circumference by the use of a magnetic adsorptive supporting means.

6. The method according to claim **4**, wherein each inner yoke-attachment laminated magnetic sub-body is formed by coupling a predetermined number of the inner yoke-attachment magnetic core sub-pieces having different lengths from a magnetic pole portion to an end of the inner yoke sub-portion and a convex engagement portion and a concave engagement portion are formed at both ends of the inner yoke sub-portion, respectively, and

- wherein in the forming the intermediate assembly, the convex engagement portion of each inner yoke-attachment laminated magnetic sub-body is inserted into the concave engagement portion of the inner yoke-attachment laminated magnetic sub-body adjacent thereto.

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